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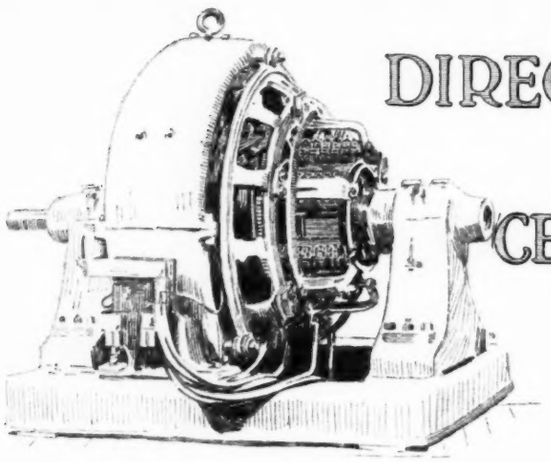

DIRECT-CURRENT MOTORS FOR DRIVING CENTRIFUGAL PUMPS

By

*Nathan Wilkinson**

Their application in water works and other variable-speed service. Heavy starting torque and efficient methods of speed variation are desirable characteristics possessed by the direct-current motor.

THERE are many installations where only direct current is available, and hence the direct-current motor is the only solution to the power problem. There are other installations where an adjustment in speed is necessary, and in these cases the direct-current motor is peculiarly adapted. Induction and synchronous motors are essentially constant-speed machines, and furthermore, the speeds are limited. For a 60-cycle installation the synchronous speeds are 1800, 1200, 900, 720, etc. On the other hand, the direct-current motor can be designed for any definite speed, and this speed can be increased or decreased by a corresponding change in the voltage at the armature terminals, or if the voltage is constant, the speed can be increased by weakening and decreased by strengthening the shunt field or by inserting resistance in the armature circuit.

To show the desirability of adjustable speed for centrifugal pumps in certain cases, a short review of its characteristics is necessary. In the article by T. M. Heermans on "Horsepower Requirements of Centrifugal Pumps," published in *Power*, May 20, 1919, the following paragraph appears:

> The amount of useful work done is known as the water horsepower and is equal to the weight of water lifted a certain number of feet in a definite length of time. Since pump capacity is usually expressed in gallons per minute (g. p. m.), and a gallon of water weighs 8⅓ lb.,
>
> *Work done per minute* = *g. p. m.* × 8⅓ *lb.* × *feet head*
>
> and as one horsepower is equivalent to lifting 33,000 lb. one foot in one minute, water horsepower,
>
> $$W.\ hp. = \frac{g.p.m. \times 8\frac{1}{3} \times feet\ head}{33{,}000} = \frac{g.p.m. \times feet\ head}{3957}$$
>
> In the preceding formulas the head not only consists of the height the water has to be lifted, but also includes the head lost by friction in the piping and the head required to make the water flow through the piping at a given rate; that is, the total head equals the static lift plus pipe friction plus velocity head.

A centrifugal pump operated at a definite speed develops a definite head. A decrease in speed reduces the head, and an increase in speed raises the head. Since the gallons per minute are determined by the head required to make the water flow through the piping at a given rate—that is, the velocity head—and since the total head equals the static lift plus pipe friction plus velocity head, it is apparent that, for a given total head—that is, given speed of pump—an increase in the static lift or pipe friction will cause a decrease in the velocity head and thus a decrease in the quantity of water delivered.

An increase in the static head or pipe friction will also reduce the horsepower required from the motor, and to deliver the required gallons per minute it is necessary to increase the speed of the pump to obtain the required increase in velocity head.

On the other hand, a decrease in static head or pipe friction will increase the velocity head and thus increase the gallons per minute and, consequently, increase the horsepower required from the motor. In this case it is necessary to reduce the speed of the pump and thus reduce the volume of water and the load on the motor. It is therefore apparent that where it is necessary to operate a centrifugal pump at different static heads of different lengths of piping, a direct-current motor is better adapted for the work than either an induction motor or a synchronous motor.

Where the voltage is constant, either the shunt-wound or compound-wound direct-current motor can be successfully used in starting and operating centrifugal pumps. In most cases the ordinary starting box is required. Where slight speed adjustment is necessary, a starting box permitting of a small decrease of the shunt-field ampere-turns is required. For a large speed adjustment where the power required by the centrif-

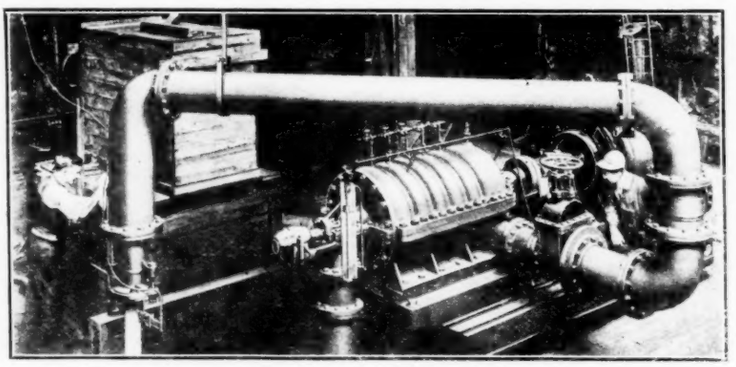

FIG. 1. MOTOR-DRIVEN SIX-STAGE CENTRIFUGAL PUMPING UNIT UNDER TEST

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ugal pump drops off rapidly with the decrease in speed, the starting box and speed regulator are arranged to reduce the speed below the normal speed of the motor by insertion of armature resistances and to increase the speed above normal by field weakening. Where the voltage is variable, as is sometimes the case with temporary installations, especially when fed from an electric-railway circuit, a compound direct-current motor should be used for the reason that an increase in voltage adds to the speed of a shunt motor, thus increasing the velocity head and overloading the motor. With a compound-wound motor an increase in load decreases the speed, which partly compensates for the increase in speed due to increase in voltage. Hence there is less variation in speed and head due to variation in voltage in a compound motor than in a shunt motor. However, the characteristics of a direct-current motor, whether it is a shunt- or compound-wound, are such that a slight speed adjustment is desirable for centrifugal pump drive for the following reason:

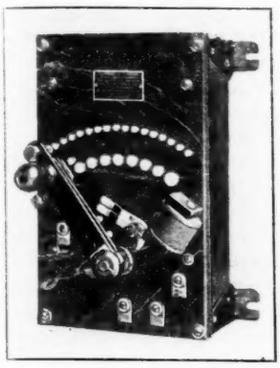


FIG. 2. STARTING BOX FOR SHUNT-FIELD CONTROL

A direct-current motor will run at a lower speed when it is cold than when it is hot, because its shunt-field windings have less resistance when cold and consequently allow more current to flow through them. This of course strengthens the field magnetism and lowers the speed of the motor. The speed is not lowered in inverse proportion to the field strength owing to the fact that the internal resistance of the motor is also lower when cold, which tends to increase the speed of the motor, but in most cases the field strengthening more than offsets the effect of the cold internal resistance and the motor runs at a lower speed when cold then when hot. The time required for the shunt fields to reach their maximum or operating temperature varies from two to six hours, depending on the size and characteristics of the motor. In the meantime the pump will operate at a speed somewhat below normal and its capacity will be reduced. In fact, the writer knows of one case where the speed was lowered to such an extent that the pump did not discharge any water at all until the motor heated up and reached its normal speed. Of course, this would occur only where the friction head was low in proportion to the total head.

In the case cited the difficulty was overcome by putting a rheostat in the shunt fields of the motor so that the speed could be brought up to normal at all times. This rheostat should be supplied with every direct-current-motor-driven pump. It can be combined with the starting box as in Fig. 2.

A city water-works plant is an admirable application of direct-current motor drive for centrifugal pumps. For domestic service the pump has to supply water at a constant pressure and variable capacity. To meet this condition the pump speed must vary, since the friction head varies with the amount of water used. The speed variation can be automatically secured by placing a rheostat in the motor-field windings and operating it directly from a pressure regulator, and the water pressure maintained constant regardless of the amount of water used. If a high pressure is desired for fire service, another regulator can be cut in by means of a throw-over switch and a higher pressure maintained.

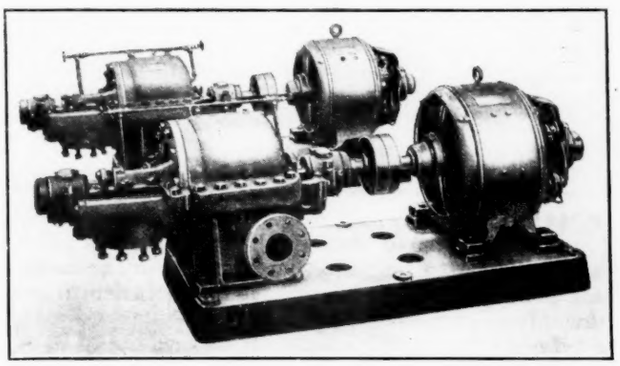


FIG. 3. MULTI-STAGE PUMPS DIRECT-CONNECTED TO DIRECT-CURRENT MOTOR

With constant-speed motors the usual method resorted to is to have two pumps and run them in parallel for domestic service and in series for fire service. This, of course, gives more water for domestic use than for fire service, which is just the opposite to what is desired because the fire demand may come just when the domestic demand is greatest. A variable-speed pump, therefore, more nearly approaches the condition desired.

Another application peculiarly suited for direct-current motors is dock service, where a constant capacity at a variable head is required and can be secured by using a variable-speed motor. In summing up it can be stated that outside of a few special cases, such as submerged motors, etc., the direct-current motor can be used for driving centrifugal pumps wherever induction or synchronous motors can be used. In addition to having all the desirable characteristics of the alternating-current motor, it has an inherently heavy starting torque and a more efficient method of speed variation than either of the other types.

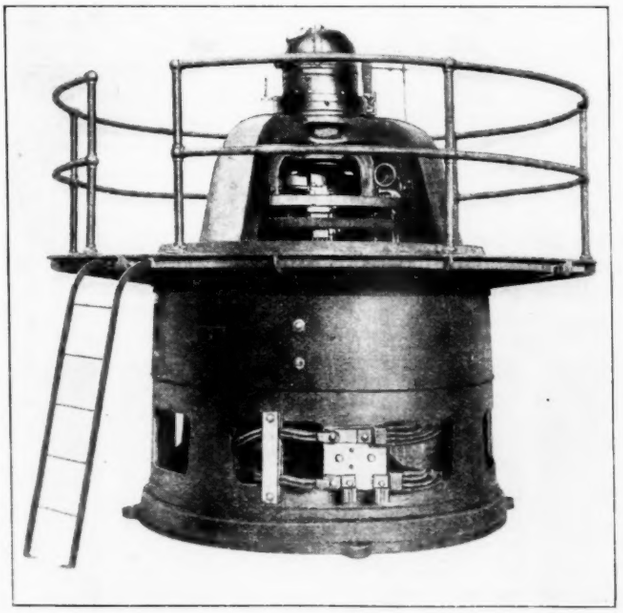


FIG. 4. LARGE VERTICAL DIRECT-CURRENT CENTRIFUGAL-PUMP MOTOR

The low-grade bituminous coals available for fuel in this country vary in heat value from 8000 to 9000 B.t.u., where the high-grade coals vary from 14,000 to 15,000 B.t.u.

Burning Lignite on Forced-Draft Chain Grate

By H. F. GAUSS*

Lignite containing 33 per cent. moisture dried in induction zone at front of stoker. With grate to heating surface ratio of 1 to 43 obtained at fair efficiency 125 per cent. of normal boiler rating. Maximum rate of combustion 40 lb. of fuel per square foot of grate area.

COMPARATIVELY few engineers have been called upon to burn lignite under boilers. It is safe to say that only those located in the immediate vicinity of lignite mines have had occasion to use it so. Much work has been done, however, by furnace designers and stoker companies in an endeavor to develop a means of burning lignite efficiently and in sufficient quantities to make the fuel suitable to the modern boiler room. Efforts so expended have not been in vain, and the time is fast coming when lignite will be recognized as a desirable fuel for the cheap generation of power.

The writer recently had an opportunity to conduct some experiments in burning lignite on the Illinois forced-draft chain-grate stoker. In conducting this work the object in view was to burn this fuel as received without any attempt to dry it out or prepare it especially for burning. Practically all previous attempts to burn lignite have been made on fuel that has been stored outside for several months and thus allowed to lose most of its moisture. In this work, however, the lignite was unloaded directly from the cars in which it was received from the mines, crushed to about 1½-in. size and fed into the stoker hopper. An approximate analysis of the fuel used was as follows:

Moisture, per cent	33.07
Volatile combustible matter, per cent	29.83
Fixed carbon, per cent	26.77
Ash, per cent	10.33
British thermal units, dry basis	10,599
British thermal units, original basis	7,094

It was anticipated that the difficulty of igniting a fuel containing so great a percentage of moisture would be overcome by the use of a special induction zone at the front of the stoker. As brought out in the previous description, this induction zone consists of a tuyere constructed exactly as the blowing tuyeres, but connected with an exhaust fan which draws some of the gases from the furnace down through the green fuel under the ignition arch.

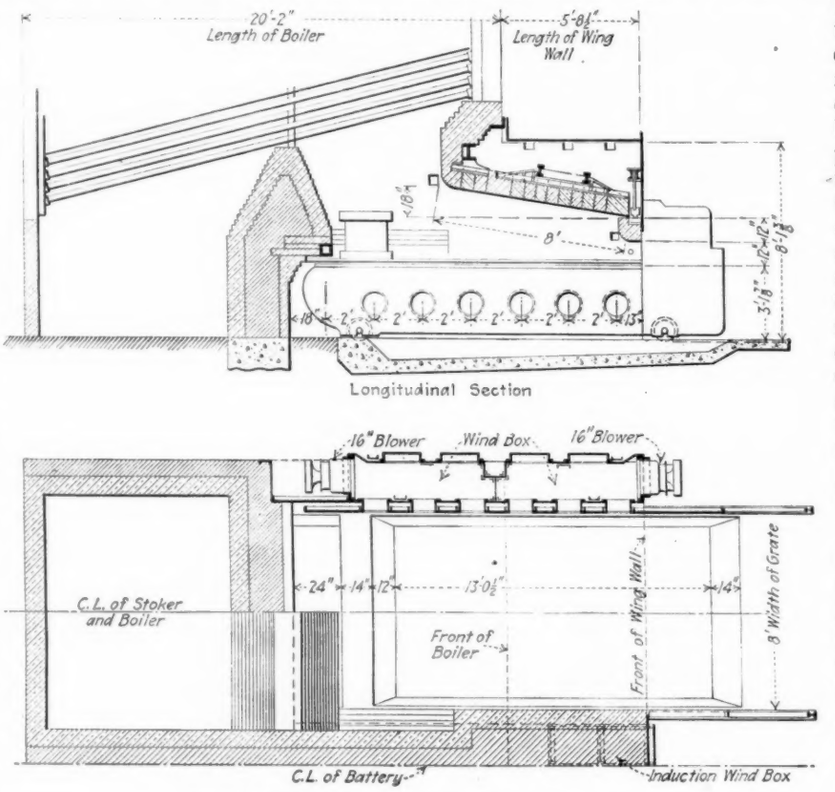


FIG. 1. SETTING FOR FORCED-DRAFT CHAIN GRATE UNDER 450-HP. BOILER

Fig. 1 shows the layout of the stoker. It was at first thought desirable to discharge the induction fan into one of the pressure tuyeres as is done when burning higher grades of coal. So much moisture collected in this discharge, however, that it was decided to pipe it directly into the smoke-stack. Careful analysis of the gases thus discharged showed 3 to 4 per cent. of CO_2 and no CO. The temperature was high and no doubt some

*Chief Engineer, Illinois Stoker Company.

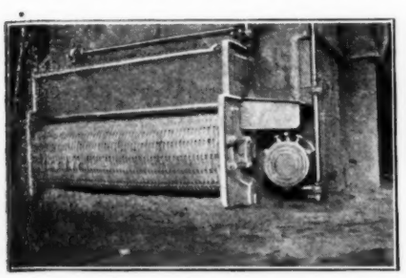


FIG. 2. FRONT VIEW, SHOWING LAYOUT OF STOKER

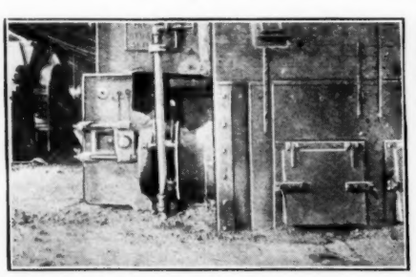


FIG. 3. SIDE VIEW WIND BOX, SHOWING 16-IN. BLOWER

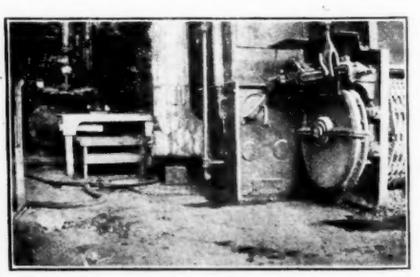


FIG. 4. INDUCTION WINDBOX AND DISCHARGE PIPE TO STACK

loss was sustained from this cause, but the gain in prompt ignition more than offset the loss. After connecting the discharge from the induction fan into the stack, it was found that the stack suction alone was sufficient to maintain ignition and the induction fan was necessary only for starting up.

Figs. 2, 3 and 4 are photographic reproductions of the installation. Figs. 2 and 3 show the windbox and one of the 16-in. blowers used to supply air to the stoker. Another 16-in. blower is similarly situated at the other end of the windbox. A partition at the middle of the box permits the two fans to operate independently of each other.

In Fig. 4 is shown the induction windbox on the opposite side of the stoker and the discharge pipe leading to the stack. The stains on this pipe were caused by water trickling down through the joints. The moisture, withdrawn from the fuel during ignition, had condensed in the discharge pipe. The induction fan is placed inside of the windbox, being supported in a partition in the box. It takes its suction from the first tuyere and discharges into the pipe leading to the stack.

An action peculiar to chain-grate stokers was observed, especially in attempting to burn lignite that had dried out and thus lost much of its moisture. The fuel in this condition ignited freely and burned well for the first few feet of grate travel. The ignition, however, did not penetrate to the bottom of the fuel bed, and a little brittle crust formed over the entire surface of the fuel bed, which interfered seriously with combustion.

After experimenting it was found that wetting the fuel before firing eliminated this trouble. It is known that the successful operation of any chain-grate stoker depends to a large extent upon providing the proper amount of moisture in the fuel. Illinois bituminous coal burns best when the free moisture in it is between 15 and 20 per cent. It was not to be expected that lignite would require any additional moisture, but the results of these experiments established the fact that it does. About 5 per cent, of water was added before the fuel was fired, and the action appeared to be a breaking up of the fuel bed as the combustion progressed, owing to the explosion of the steam generated in the fuel bed. The crust of fused ashes on top did not form, and ignition penetrated to the bottom of the bed.

The work has not been carried to completion, but thus far no trouble has been experienced in obtaining from 100 to 125 per cent. of normal rating at a fair efficiency. Higher ratings can be secured by providing more grate surface. The water-tube boiler used in the tests was rated at 450 hp. The grate was 8 ft. wide by 13 ft. long, containing 104 sq. ft. of surface, including the induction zone. The maximum rate of combustion was 40 lb. per sq. ft. of grate area.

Efficient Operation of Power Plants

By F. C. TORRANCE

The writer tells how to go about plotting curves of boiler, turbine and auxiliary performance, and station performance, so that the plant may be at all times operated at the highest efficiency for the load carried.

IN THE design of a modern station, the gages for guiding operation are, in their way, just as important as the main units. For example, the boilers are equipped with air-pressure gages for forced draft; draft gages, both furnace and under damper; thermometers for water and steam temperatures; and either meters for measuring the water fed to each boiler or flow meters for recording the steam discharged from each boiler. A good many stations also supply their firemen with CO_2 recorders for further checking combustion. In the turbine room the steam fed to each turbine is measured, as well as the pressure and temperature of the steam. In this way the engineer has a constant check on the performance of the station and can constantly check the operators.

How to Use the Instruments

How shall they be used? Before the engineer in charge can direct his men as to the points at which the different boilers should be banked, or the main units and auxiliaries cut in or out of service, he must first determine this for himself. Of course, the only way to accurately obtain this information would be to run tests on all the different types of apparatus and from these results direct the operation of the station. This would take several months, and some steps should be taken to operate as efficiently as possible during the time that the tests are being run.

The easiest way to accomplish this is to take the manufacturers' guarantees as a basis for calculation. In the newer stations, where these guarantees are all available, this should be a fairly simple matter.

As an example, assume a station with a 24-hour load curve similar to that shown. This station has eight boilers, each of 11,400 sq.ft. heating surface, and three 20,000-kw. turbines for carrying the load, but all the boilers and turbines are not needed at all hours of the day. The boilers have multiple-retort underfeed stokers. The first consideration is whether the station units (boilers, turbines and auxiliaries) are being operated in such a way as to give the best water rate on the station and at the same time carry the boilers at their best rating.

The station in question is equipped with steam-driven auxiliaries, the exhaust from which, in excess of that required for the economizers, is fed into one of the lower stages of the main turbine, so that none is wasted. The problem, then, is to determine the total station water rate for this 24-hour load, and having determined it, a study of the operation can be made with a view to cutting the units on and off the line at such points as would give the best station water rate and efficiency.

This station is equipped with surface condensers, hotwell pumps, circulating pumps, wet air pumps, boiler-feed pumps, house-service pumps and forced-draft fans. All the pumps and fans are turbine-driven.

Water-Rate Curves

Before proceeding further, guarantee curves for this apparatus must be drawn. Knowing the load at each hour of the day and the different units operating, it is a comparatively simple matter to draw up water-rate curves, not only for each individual unit, but for the entire station. This is done and is shown for the main units and for the auxiliaries, while a combined water-rate curve also is shown.

One of the first points to be noticed after inspecting the results is the fact that the second main unit was

started up too soon in the morning. This is evident after inspecting the different curves. The first additional machine was started fully one hour before needed, allowing half an hour for variation in load, and the third machine was put on the line two hours and a half too soon. This is shown where the station load and curves of boilers and turbines operating are plotted. It is also shown on the water-rate curve for the main units and also on the water-rate curve for the entire station.

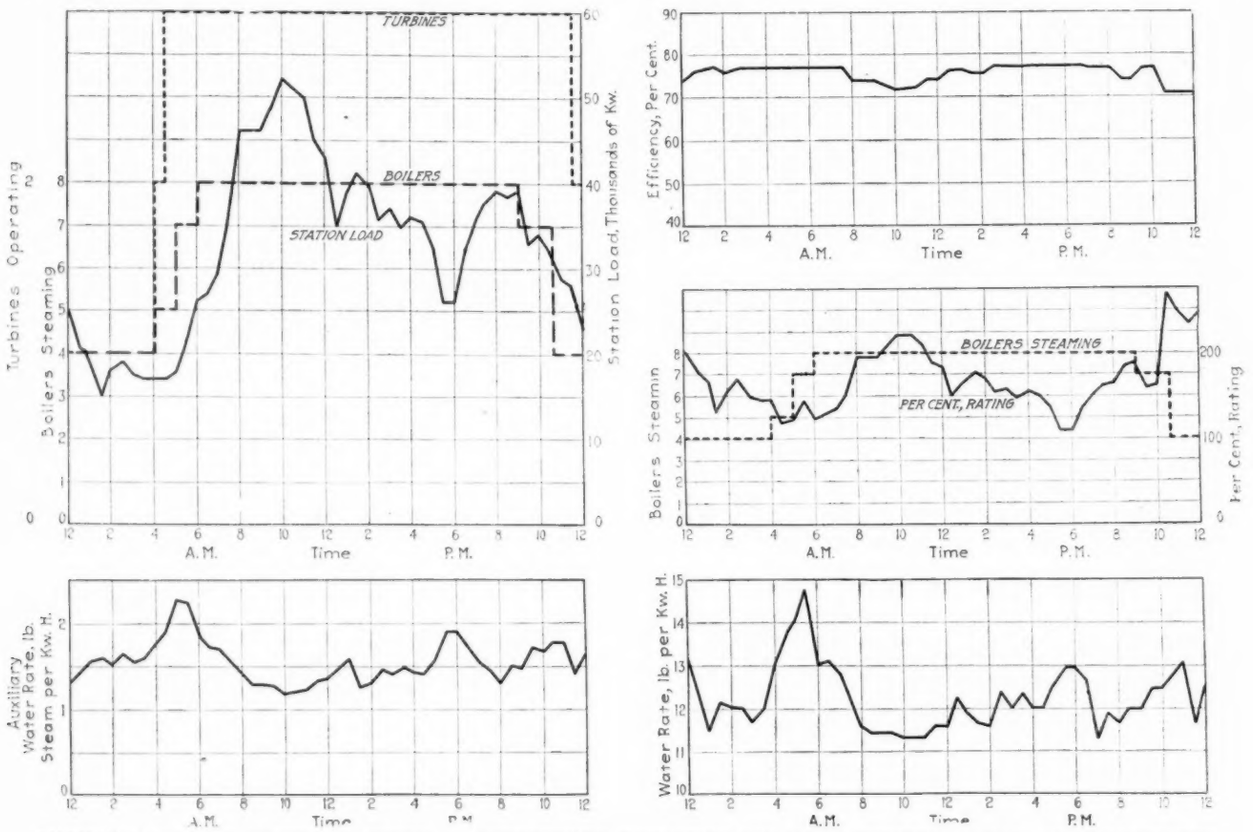
A study of these curves shows that the station water rate increased excessively at approximately 4 o'clock in the morning, at which time the second machine was being started, and the water rate did not get back to normal until 8 o'clock. If the second unit had not been put on the line until 5 o'clock and the third until 7 o'clock—which would have given ample time—this increase in water rate could have been largely done away with, and the average station water rate would have been somewhat lower.

Another point to be considered in this connection is the boiler operation; that is, whether the different boilers are operated so as to give the best results. A combined operating, rating and efficiency curve for the boilers is shown and indicates that the boiler operation was nearly normal, with the exception of the period from 10 p. m. to midnight, at which time the units were taken off the line too rapidly.

The foregoing results, of course, are based upon manufacturers' guarantees, and while they are likely accurate to a reasonable degree, they should be checked up with tests of the actual performance of the various apparatus, after which an accurate performance curve could be worked up and followed.

These results clearly show that too much care cannot be taken in starting and stopping the equipment of a station. The station equipment must be carried at its most efficient load at all times, and at the same time care must be taken that the combination of boilers and turbines operating is flexible enough to care for any reasonable increase in load. This can be done with a great degree of accuracy after the operator has made a study of the station-load curves for the various seasons of the year.

Having determined these conditions for himself, the engineer should instruct the operators, so that the station may be run at all times at greatest efficiency. This can be helped further by posting the results of station performance from day to day, so that the men may know at all times just what they are doing. This will increase interest and cause a friendly rivalry between the shifts, which will undoubtedly tend toward better results all around.



SHOWING VARIOUS CURVES PLOTTED TO DETERMINE EFFICIENT RELATION BETWEEN LOAD AND EQUIPMENT IN SERVICE

CORRECTION—It has been pointed out by the Hagan Corporation, Pittsburgh, that the article appearing in the Oct. 21 issue of *Power*, pp. 610-11, describing the Hagan Combustion Control Regulator, may give the impression that the chart was taken from a stoker windbox. Such was not the case. The chart was drawn by a pen attached to the chain connection from a Hagan Master Regulator to a damper in the stack. The article stated that the chart showed a movement of the Hagan Roto Valve, while in reality it indicated the movement of the Hagan Regulator during a 24-hour period, and the notations "Inches Water Gage" on the chart were reproduced through an error.

Gas Measurements with Plain Orifices

By A. H. BLAISDELL

Directions for using orifices for the measurement of the flow of moisture-laden gases. Gives a formula for such use with a curve showing coefficients and a drawing of the necessary arrangement of the apparatus when these coefficients are applied. An illustrative problem is solved and the result compared with that from the simpler dry-gas formulas.

THE plain orifice, either with sharp-edged or rounded entrance, has become a standard means of measuring rate of gas flow, and when properly installed and calibrated, offers a very convenient and accurate method for such measurements. Much experimenting has been carried out in order to determine discharge coefficients for orifices under different conditions of flow, and simplified formulas have been developed with which these coefficients might be used. These formulas are fairly satisfactory when used with bases containing only a small amount of moisture, but since in most cases the moisture content is large, it seems desirable to develop a formula which will, when used in connection with a plain orifice, give reliable values for the rate of flow of dry gas regardless of the amount of water vapor in the gas.

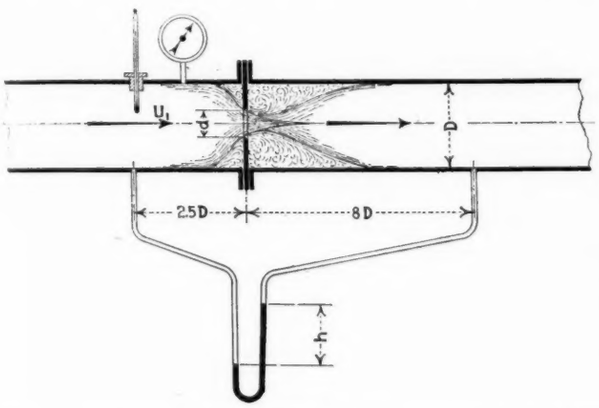


FIG. 1. ORIFICE APPARATUS FOR MEASURING GAS FLOW

The sharp-edged orifice or throttle-disk can be easily located in a pipe line by being slipped in between flanges, as shown in Fig. 1. The disk causes "wiredrawing" or "throttling," resulting in a drop of pressure, the drop increasing with the rate of discharge. In the high-pressure region, or upstream side of the disk, the gas flows with a velocity U_1. As it passes through the orifice into the low-pressure region, the velocity increases, but this increased velocity is not maintained since the energy of the jet is dissipated when the gas flowing through the orifice enters and mixes with the gas in the low-pressure region. Eddies are produced, and the increase of kinetic energy is returned to the fluid in the form of heat.

CERTAIN PROPERTIES OF VARIOUS GASES

	Molecular Wt. (M) of Gas	Wt. per Cu. Ft. at 62° F. and 14.7 Lb. per Sq. In.	Gas Constant R
Air	28.95	0.0761	53.34
Methane (CH_4)	16.02	0.0421	96.31
Ammonia (NH_3)	17.06	0.04483	90.50
Carbon dioxide (CO_2)	44.00	0.1156	35.09
Carbon monoxide (CO)	28.00	0.0734	55.14
Hydrogen (H_2)	2.016	0.00529	765.86
Oxygen (O_2)	32.00	0.0840	48.25
Nitrogen (N_2)	28.08	0.0737	54.99
Water (H_2O)	18.02	.....	.....

For small pressure differences, say up to 2 per cent. of the absolute gas pressure, it is permissible to assume the gas density as being practically constant. In that case it is easy to show that the weight of dry gas flowing through a throttle disk in pounds per second is

$$W = \frac{0.0125\, C\, d^2}{R_g} P_g \sqrt{h\delta \frac{R_m}{P_m T}} \qquad (1)$$

where

W = Pounds per second of dry gas;
C = Velocity coefficient;
d = Diameter of orifice in inches;
P_g = Partial pressure of the dry gas in pounds per square inch absolute;
R_g = Gas constant for dry gas;
h = Differential in inches (see Fig. 1);
δ = Density of liquid in differential gage;
R_m = Gas constant for mixture of gas and vapor;
P_m = Combined or total pressure of mixture in pounds;
T = Temperature of mixture in degrees F. absolute.

The results of very carefully conducted tests[1] have indicated that the coefficient C varies with the ratio of the orific diameter to the pipe diameter, and values of C from these tests are plotted in Fig. 2. When using these values in actual tests, it must be remembered that part of the pressure drop occurs in the pipe and consequently the distance of the differential gage openings from the throttle disks must be proportional to those used in the calibration; therefore, the values given by the curve of Fig. 2 can be used only when the gage openings are located as indicated in Fig. 1.

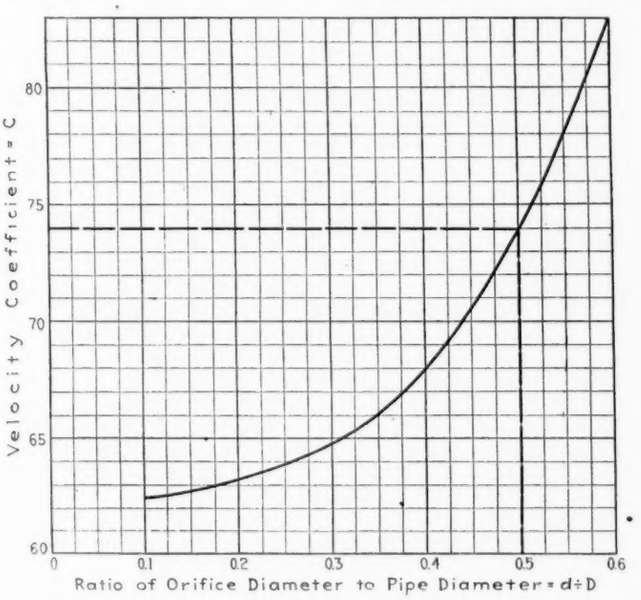


FIG. 2. VELOCITY COEFFICIENT FOR GAS ORIFICES

The accuracy of formula (1) is affected to some extent by the magnitude of the velocity U_1, or the ve-

[1] See "Zeit. des Ver. d. Ing.," Feb. 23, 1908, and the "Jour. A. S. M. E." for March, 1916.

locity of approach. However, if the ratio of the orifice diameter to pipe diameter does not exceed 0.5, then the effect of U_1 can be neglected. It should be noted that this formula gives dependable results only when the gas flow is steady. For heavy pulsations the volume discharged is proportional to the average velocity, whereas h, in the formula, is proportional to the average velocity squared.

In order to use formula (1) it is necessary that there be some means of obtaining accurate values for P_m, T, P_g and R_m. P_m can, of course, be determined by use of a pressure gage or a mercury column, located either on the upstream or downstream side of the throttle disk, but not closer than the openings for the differential-gage connections. If the moisture condition of the gas is to be considered, then the temperature T ($= t +$ 460) is the dry-bulb reading of a wet- and dry-bulb thermometer inserted in the pipe in close vicinity to the pressure gage. The partial pressure P_g of the gas can be calculated provided the relative humidity of the mixture of gas and vapor is known. In that case we have

$$P_g = [(gage\ pressure + B) - kp] \qquad (2)$$

where

k = Relative humidity;

p = Vapor pressure for saturated vapor at temperature T degrees absolute;

B = Barometric pressure in pounds per square inch absolute.

The relative humidity is most easily obtained from a humidity chart such as that of Fig. 3. The value of p can be found in any steam tables and is the absolute pressure in pounds per square inch corresponding to the absolute temperature T. Values of kp for gas temperatures ranging from 100 to 200 deg. F. and relative humidities from 10 to 100 per cent., can be secured directly from the curves of Fig. 4. The barometric pressure in inches of mercury can most conveniently be obtained by means of an aneroid barometer. Ordinarily, it will be all right to assume $B = 14.7$ lb. per sq. in. abs. The gas constant R_g is known for the gases dealt with

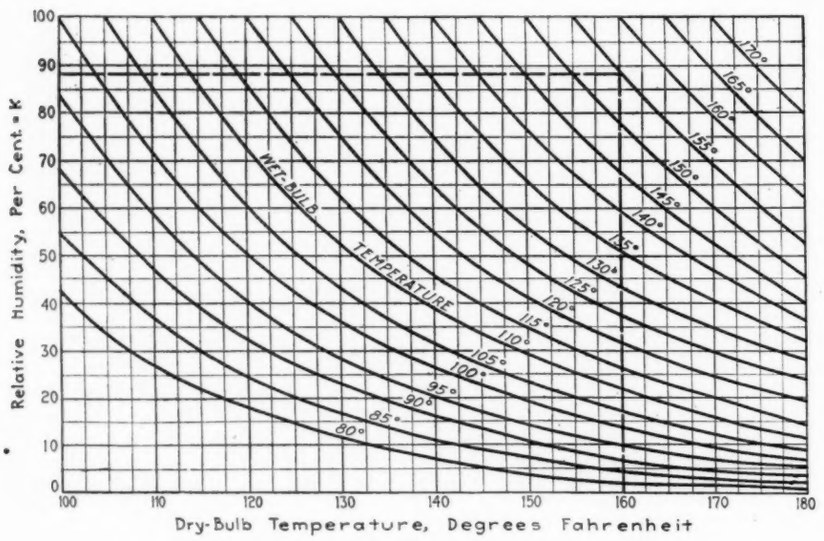


FIG. 3. CHART FOR DETERMINING RELATIVE HUMIDITY

in engineering practice. The gas constant R_m for the mixture can be figured from

$$R_m = \frac{1544\,P_m}{[M_g\,(P_m - kp) + M_v\left[\frac{kp}{P_m}\right]]} \qquad (3)$$

where M_g and M_v are the molecular weights of the gas and the vapor, respectively. (See accompanying table.)

If air is the gas to be measured and the differential h

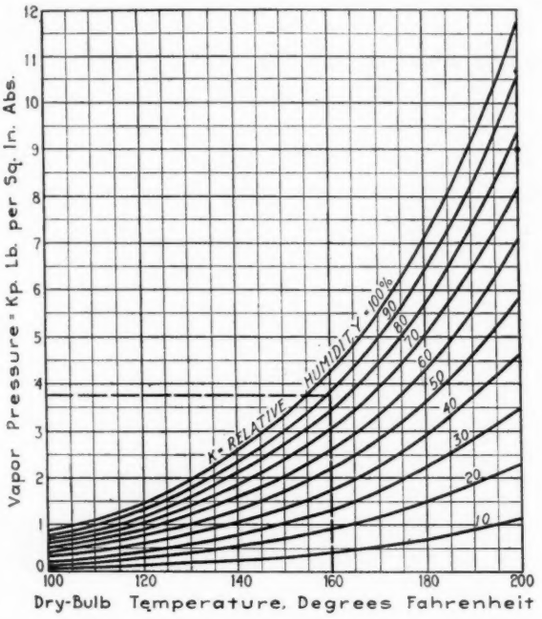


FIG. 4. VAPOR PRESSURES IN VAPOR AND GAS MIXTURES

is measured in inches of water, then formula (1) reduces to

$$W = 0.00181\,C\,d^2\,P_g\sqrt{\frac{h\,R_m}{P_m\,T}}\ lb.\ per\ second$$

For gas pressure of 25-lb. gage or less, it is best to use a mercury column instead of a low-pressure gage, since the mercury column offers a far more accurate method of pressure measurement than that furnished by any pressure gage.

Illustrative Problem: Suppose air is being delivered through a 4-in. pipe line under a pressure of 100 lb. per sq. in. gage. A 2-in. diameter orifice is inserted into the line in accordance with the foregoing directions. If the pressure drop through the throttle disk is 10 in. of water and the temperatures of the wet-bulb and dry-bulb thermometers are 155 deg. F. and 160 deg. F., respectively, and the barometric pressure $B = 14.7$ lb. per sq. in. abs., what will be the rate of discharge in pounds per second of dry air:

Referring to Fig. 2 we find that for $\frac{d}{D} = \frac{1}{2}$ $C = 0.74$. From the humidity chart, Fig. 3, for a dry-bulb temperature of 160 deg. and a wet-bulb temperature of 150 deg. the relative humidity is given as 89 per cent. Now, referring to the curves of Fig. 4, we find that a dry-bulb temperature of 160 deg. and a relative humidity of 89 per cent., that the vapor pressure kp is about 3.8 lb. per square inch absolute.

Therefore, the partial pressure P_g of the dry air is

$$(100 + 14.7) - 3.8 = 110.9\ lb.\ per\ sq.\ in.\ absolute$$

$$\text{Constant } R_m = \frac{1544 \times 114.7}{29\,(114.7 - 3.8) + 18\left[\frac{3.8}{114.7}\right]} = 55.2$$

Hence the weight of dry air discharged per second is

$$W = 0.00181 \times 0.74 \times 4 \times 110.9\sqrt{\frac{10 \times 55.2}{114.7 \times 620}}$$
$$= 0.0529\ lb.$$

If W had been computed from the formula ordinarily used (which neglects the moisture constant), we would then have had

$$W = 0.0135\ C\ d^2\sqrt{\frac{h\ P_m}{T}} =$$

$$0.0135 \times 0.74 \times 4\sqrt{\frac{10 \times 114.7}{620}} = 0.0543\ lb.$$

as the rate of discharge. The difference, 0.0543 — 0.0529 = 0.0014 lb. per second, or 0.084 lb. per min., indicates the error (2.75 per cent.), which results when moist air is the gas being measured. It seems self-evident, then, that the relative humidity must play an imporant rôle in the measurement of commercial gases, whether air or otherwise.

De Waters Safety Latch

As a matter of safety to the fire-room force, every boiler furnace should be fitted with some type of safety firing door so that in case of a bursting tube the live

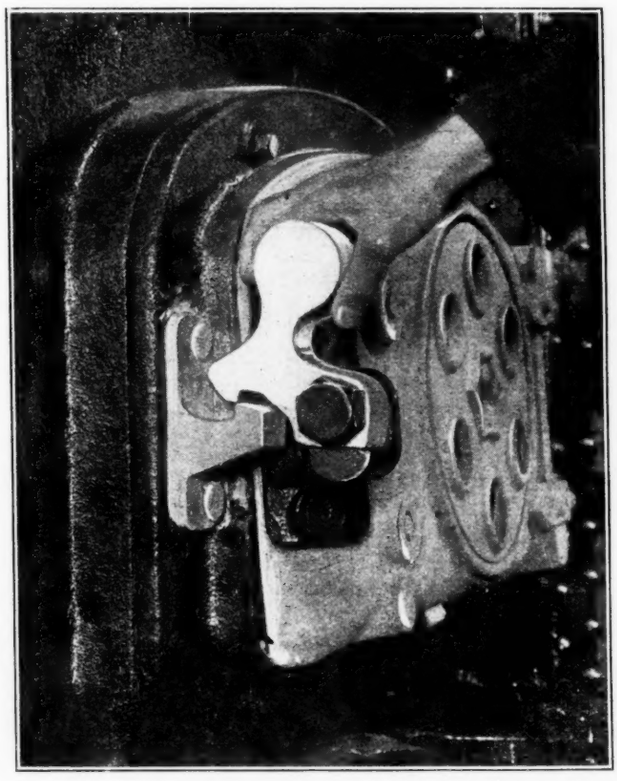


FIG. 1. DE WATERS LATCH APPLIED TO A FURNACE DOOR

coal, steam and water cannot be blown out of the furnace upon the men who are operating the boilers.

Several designs of furnace doors have been used. A device that has recently been developed for safeguarding the firemen is known as the De Waters safety latch, shown in Fig. 1. It consists of an L-shaped member D (Fig. 2) pivoted at one end at E, a weight W on the upper end of the vertical length of the L and a latch base B. The movement of the latch is controlled by two

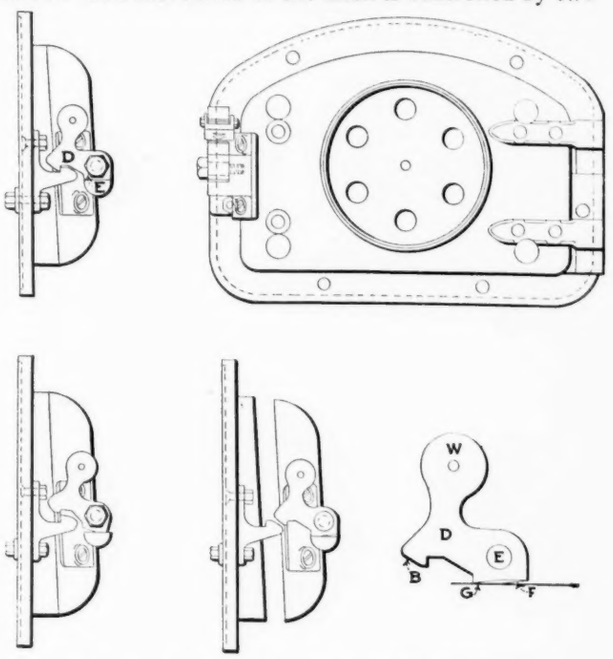


FIG. 2. DETAILS OF THE SAFETY LATCH

bevel stop faces—F, which restricts the movement in the open position to the amount required to clear the latch keeper, and G, which limits the closing movement and brings the latch nose to a vertical contact with the

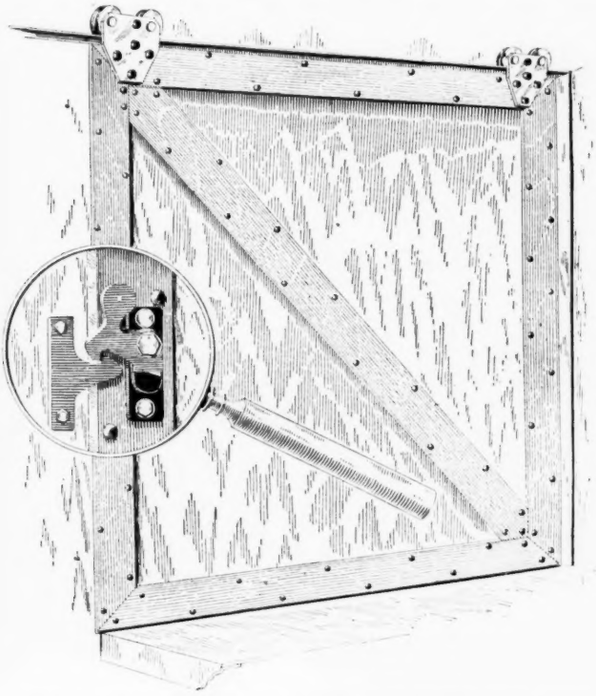


FIG. 3. APPLICATION TO A FREIGHT ELEVATOR DOOR

keeper which holds the door securely locked until it is opened by pulling back on the weight W. This device is manufactured by the De Waters Safety Latch Co., Central Avenue, Far Rockaway, N. Y., and can be applied to any ordinary furnace door.

Two New Vilter High-Speed Ammonia Compressors

DEMAND for a small high-speed compressor that will operate noiselessly at high efficiency and require a minimum of attention led the Vilter Manufacturing Co., of Milwaukee, to develop the compact single-acting inclosed machine shown in Fig. 1. Capacities range from ½ to 18 tons refrigeration, cylinder sizes from 2.5x2.5 in. to 7.5x7.5 in. and the speeds for the different sizes range all the way from 149 to 515 r.p.m. As small motors are not built for speeds much less than 500 r.p.m., the compressor is belt, chain or gear driven.

For these speeds plate valves are employed. The suction valve is of the same type used in the larger machines. It is made of one or more thin steel rings hardened and ground to the surface. The rings are held in place by helical springs, and both are secured between two cages fitting closely together and occupying little space. The suction valve is in the piston. Ammonia vapor is drawn into the cylinder during the downstroke. The change in direction of piston movement, augmented by the action of the springs, closes the valve for the upstroke.

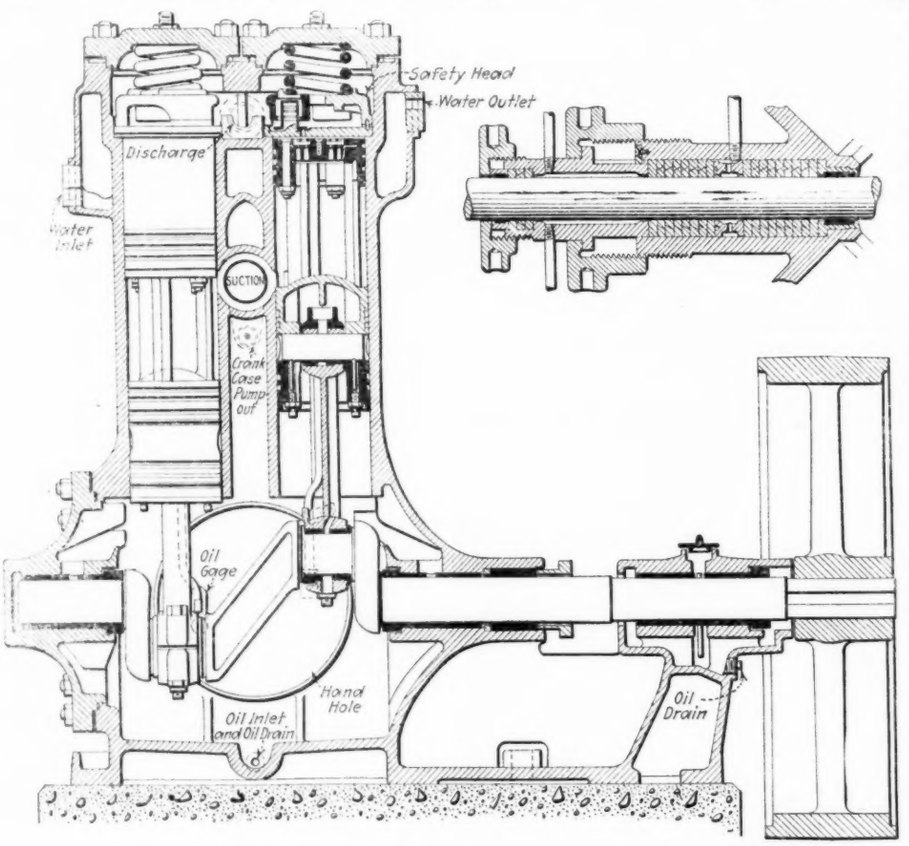


FIG. 1. SECTION OF VILTER INCLOSED-TYPE TWIN VERTICAL AMMONIA COMPRESSOR

The discharge valve is in the compressor head. It is of a modified plate type, Fig. 2, with a cylindrical recess making a tight running fit with a cylinder projecting from the safety head of the compressor. Light helical springs hold the valves in place, and a heavy spiral spring secures the safety head, permitting small striking clearance. Depending upon the area required, the discharge valve may be single or in multiple.

One of the troubles to which high-speed machines of this type are subject is oil getting past the piston and draining the crankpit, especially as they are supposed to have only occasional supervision. To guard against this difficulty in the present design a double trunk piston, with piston rings to stop both ammonia and oil, has been employed. Sufficient space has been allowed between the two parts of the piston for clearance opposite the suction-gas inlet, and as evident in Fig. 1, there is plenty of room for the required number of snap rings to prevent leakage of ammonia and on the lower part of the piston sufficient space for special oil rings and oil grooves.

Owing to its speed the compressor has large capacity for its size and the floor space occupied. Its operation is practically noiseless, and in service it is reported to have given excellent results.

In the accompanying illustrations are shown the details of the horizontal, double-acting, high-speed ammonia compressor recently perfected by the company. It is built in capacities ranging from 30 to 411 tons with maximum speeds of 164 r.p.m. for the largest size, having cylinder dimensions of 19x19 in., to 327 r.p.m. for a 9x9-in. compressor. To withstand the service, the rolling-mill frame with slight modification is used exclusively for all sizes of compressors. It is cast separate from the cylinder, and a feature out of the ordinary is the method of fastening the cylinder to the frame. Two separate sets of studs are employed, one for the frame and the other for the crank-end cylinder head. With this construction any distortion that might occur in the frame under severe operating conditions is not communicated to the head. With its own tongue-and-groove joint and its own studs, the head is independent of the frame, so that it is a simple matter to maintain a tight joint. The cylinder connection to the foot allows freedom of movement to take care of expansion or contraction. The heads are the only parts of the cylinder that are water-jacketed.

As shown in Fig. 3, the valve chambers, of which there are eight at each end, four for the suction valves and four for the discharge valves, are arranged around the barrel near the end of the cylinder and are an integral part of the cylinder. The four upper chambers are connected to the suction and the four lower ones to the discharge header. The valves, Fig. 4, are all identical in construction, but of different sizes. Each of

these special plate valves is made up of one or more thin steel rings hardened and ground down to surface. The rings are held in place by light helical springs, and all is secured within two cages fastened together with a

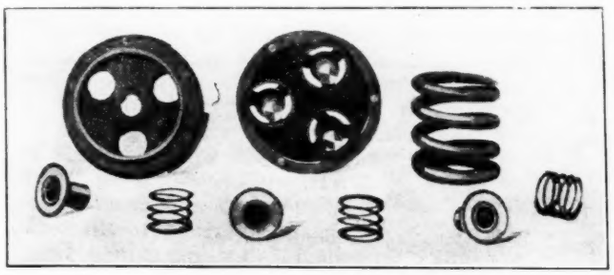


FIG. 2. MODIFIED PLATE VALVE

machine screw. The valve cage is held in position in the chamber by a steel stud having threaded connection to the cover plate and made tight by a special nut on the outside. The machine screws referred to simply hold the two parts of the valve together, and the springs and plates in place while assembling and handling. After the valve is in position and the studs screwed down, pressing the cage on the shoulder, which is a ground joint, no strain can be exerted on the machine screws.

The transverse section of the compressor is shown in Fig. 3. It will be understood that the rings or plate-type valve automatically cover or uncover the ports,

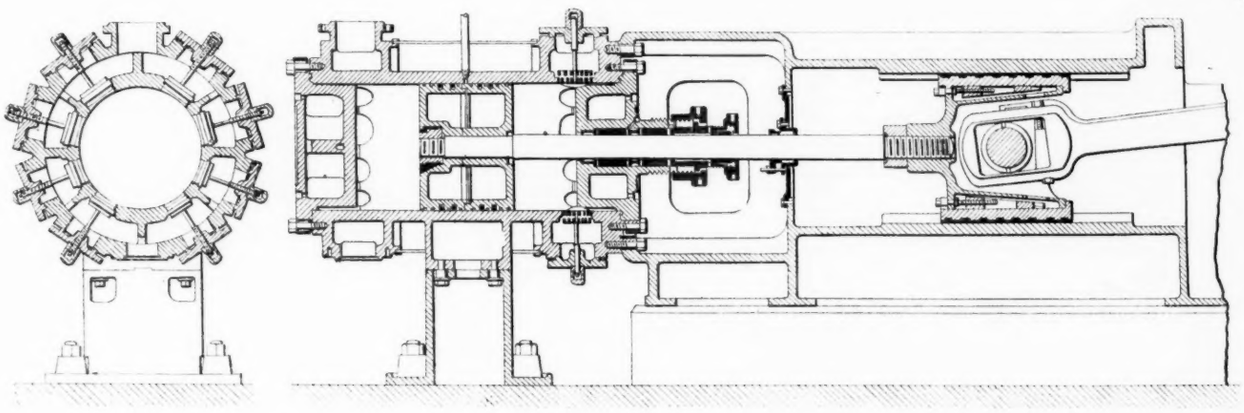


FIG. 3. SECTIONAL VIEW OF VILTER HORIZONTAL HIGH-SPEED AMMONIA COMPRESSOR

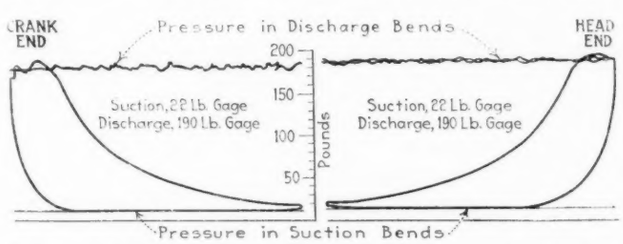


FIG. 4. INDICATOR DIAGRAMS FROM THE COMPRESSOR

depending upon the pressure or suction within the cylinder acting against the spring holding the valve. The action is noiseless, and with practically no inertia, due to the lightness of the plate, the design is conducive to high speed. With the large valve area allowed by the construction, gas velocities are maintained within moderate limits. Excessive piston speed is prevented by shortening the stroke of the compressor piston. In the past it has been quite generally claimed that clearance tended to increase the required horsepower per ton of refrigeration of a compressor, but the basis for this contention has never been set forth in a clear manner. It was never shown that theory could be used in any way so as to uphold the assertion. On the other hand, the formula used in thermodynamics to express the mean effective pressure of a compressor diagram depends only upon the suction pressure and the relation it bears to the discharge pressure. Tests made to show the effect of clearance might be misleading, as changes in so many different conditions have marked effect upon the results. In this connection might be mentioned, as affecting the results, the temperature of the liquid ammonia entering the refrigerator, the temperature of gas entering the compressor, if superheated, saturated or wet, change in cylinder heating effect, etc.

With the introduction of the high-speed compressor it was necessary to make some changes in the valves, which introduced a moderate amount of clearance, as shown by the indicator diagrams in Fig. 4. The clearance is of positive benefit for the direct-connected high-speed compressor, as the compression and reëxpansion of the gas in the clearance space tends to cushion the

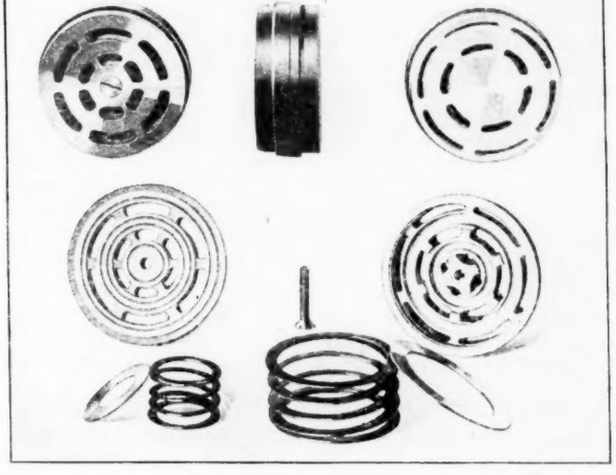
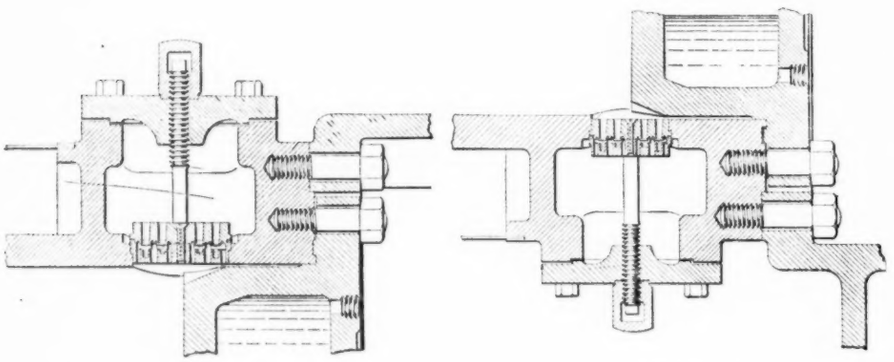


FIG. 5. PLATE VALVE FOR SUCTION AND DISCHARGE

change in movement of the reciprocating parts. The diagrams shown were taken in the usual manner and

then the indicator was opened to connections from the discharge and suction bends and lines were drawn on the cards showing these pressures as recorded by the indicator. This clearly brings out the fact that the cylinder not only completely fills with gas at the suction line pressure, but, probably due to the inertia of the gas following the piston suction stroke, fills with gas at a pressure higher than the suction line. The discharge-line pressure is only slightly above the discharge line of the diagram.

These conditions are superior to those produced by the old-type heavy poppet valve having coil springs, with some of which the pressure could not be regulated, and with others the pressure regulation was within the power of the operating engineer. It has been found by experience that many of these springs were badly regulated, requiring considerably higher pressures in the cylinder to open the discharge valves and often much lower pressures to open the suction valve. With the improved light plate valve these unfavorable conditions cannot exist. Sections of the suction and discharge valves are shown in Fig. 6.



SUCTION DISCHARGE

FIG. 6. SECTIONS OF THE SUCTION AND DISCHARGE VALVES

Use and Abuse of Fuel Oil in Power Plants

By W. J. Smith

With the return of more or less normal conditions throughout the country, oil will be used to a greater or lesser extent in power plants, but the lessons learned in the use of fuel and the generation of steam will require greater vigilance and care than was used before the campaign of economy and efficiency.

During the last few years a series of tests taken at random demonstrates that a condition very far from ideal exists in most of the plants using fuel oil, very little of which is excusable, because of the ease and facility with which very nearly perfect conditions may be obtained with liquid fuel. The relation of air supply and the atomized fuel is so easily balanced and maintained that the wasteful conditions existing would not be tolerated were those in charge cognizant of the true facts.

Why the average engineer or, for that matter, his assistant should shy at the use of apparatus that requires only a very rudimentary knowledge of chemistry is difficult to understand, in view of the fact that the same men are capable of close mechanical adjustments of complicated machinery and often understand difficult mathematical formulas. Yet there are probably more plants operating at 75 per cent. or less of the possible efficiency than there are doing better than this figure.

That the average CO_2 content of the flue gas from most of the tests mentioned does not exceed 7 or 8 per cent. under ordinary operating conditions was found. When any effort was made to build up to a higher degree of efficiency, an attitude more or less of sarcasm was met, which was rather difficult to overcome. When such a simple matter as adjustment of the damper or arrangement of the air supply entering in the hearth or furnace was involved, objections of all kinds were often raised and every effort apparently made to discredit the information gained from the gas analysis, even when diplomacy was used in making such suggestions. It is a well-demonstrated fact that any plant burning fuel oil in quantity which operates at an average of less than 13 per cent. CO content in its flue gas is operating under adverse conditions, and no engineer who thoroughly appreciates the possibilities would be satisfied with anything markedly less.

I have in mind a number of plants in which some slight adjustments or stoppage of air leakage about the settings has effected marked results and economies. For instance, one of the large steam-power plants operating in British Columbia, consuming under a full load nearly five hundred barrels of oil per day, by a change in the draft reduced this consumption by nearly fifty barrels, surely something worth going after! To go to the other extreme, a small plant with one horizontal-tubular boiler, by raising the CO_2 content from 6½ to 12 per cent. saved about three barrels per day. Many operators or firemen are in the habit of running with a large excess of air, producing a very short white flame, and together with an excess of steam for atomizing, produce conditions that lead to high velocity of the gas travel through the boiler passages and consequently high terminal stack temperature.

Instances have been frequently met where no provision existed for any close regulation of stack draft. It is necessary that there be means to regulate the damper very closely in order to produce the best furnace conditions. It is frequently necessary to make such adjustments of damper and atomizing agency that the fire has a much different appearance from that the firemen and operators have been accustomed to. However, it may safely be said that with the air supply closely balanced to the requirements and other adustments properly made, the reduction of fuel consumed will be gratifying to owner and conscientious employee alike.

A good rough and ready rule in the absence of an apparatus for determining furnace conditions is, after the fires are well alight and the furnace hot, to reduce the air supply by means of the stack damper to a point where the flame has a slight smoky appearance, then open just sufficiently to clear it. Lacking a CO_2 recorder, the use of the Orsat will enlighten the operator as to what conditions are best, and it is safe to say that he will not depart very far from them once that point is reached.

Power-Factor Adjustments by the Use of Synchronous Motors

BY ROBIN BEACH
Associate Professor, Department of Electrical Engineering, The Polytechnic Institute, Brooklyn, N. Y.

Presents in a nontechnical manner the effects of low power factor, the leading power-factor characteristics of synchronous motors, the application of synchronous motors to power-factor adjustment and the extent and effects of their corrective influence.

BECAUSE of the vast number of induction machines such as transformers, induction motors, arc lamps and various types of small devices, alternating-current circuits generally operate with lagging power factors varying over wide limits. Each individual machine or piece of apparatus has its own power-factor characteristic for its load range. Some types of machinery have rising power factor for increasing loads, others have a practically constant range, while still others have decreasing values of power factor for increasing load. It is the aggregate effect of these

TABLE I. HEAT LOSSES CAUSED AT DIFFERENT VALUES OF POWER FACTOR

Kw. Load on Machine	Power Factor, Per Cent.	Voltage at Machine	Current in Amperes	Heat Losses in Line
1000	100	1000	1000	1.00
1000	80	1000	1250	1.56
1000	60	1000	1667	2.77
1000	50	1000	2000	4.00

which determines the power factor at the distributing center. Since induction motors constitute the major portion of load equipment and their power factor increases as the load increases, the power factor in the system will be affected by the degree of loading of the apparatus. If it is all operating at full load or overload, the power factor of the system will be at its highest. If the equipment is only slightly loaded, the resultant power factor will be low. Intermediate degrees of loading will give a power factor lying between these limits.

The foregoing emphasizes the important facts that motors which run at underrated load not only mean low efficiency at additional expense to the customer, but also low power factor, which decreases the efficiency of the generating and distributing equipment. Consequently, advice with the central-station management regarding the choice of proper capacity equipment before purchase would lead to a mutually beneficial and satisfactory purchase, since machinery would be recommended the capacity of which would represent, generally speaking, the average load. Attention on the part of salesmen and electricians to giving machinery the advantage of its overload capacity rather than the too common present practice of working considerably under the rated capacity would tend toward better service throughout.

In a circuit having a low power factor it is necessary to draw a relatively large current for a given load in kilowatts with a corresponding line voltage drop. Consequently, for a given kilowatt load the line impedance drop is large for low power factor and small for high power factor. This means that the voltage regulation will vary between wide limits, which is unsatisfactory for the proper functioning of certain types of machines. The pulling power of induction motors varies as the square of the voltage, consequently if the voltage is reduced a certain percentage of normal, the torque is reduced to the square of the lower voltage.

Table I shows the relative increase in heat loss in the transmission of a given amount of energy at various power factors. The heat loss at unity power factor is taken as unity. It will be observed that the current increases rapidly for decreasing power factor. The voltage, which is assumed constant at 1000 volts, be-

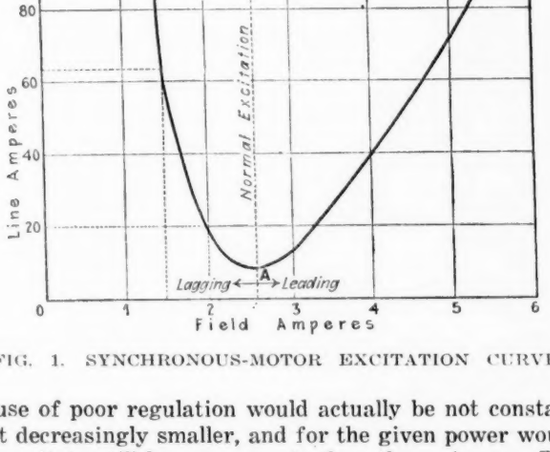


FIG. 1. SYNCHRONOUS-MOTOR EXCITATION CURVE

cause of poor regulation would actually be not constant but decreasingly smaller, and for the given power would necessitate still larger currents than those shown. The effect of low power factor is obviously bad, and measures taken to improve it are not only favored but demanded by present practice. Central plants are in some cases imposing penalties upon customers operating loads with a power factor lower than a specified value.

TABLE II. CURRENT AND POWER-FACTOR VALUES FOR THE CIRCUIT IN FIG. 2

Load Units Connected to Supply as Indicated Below	Current and Its Power Factor for Given Sections of Line: Section A to B — Current in Amp.	Section A to B — Per Cent. Power Factor	Section B to C — Current in Amp.	Section B to C — Per Cent. Power Factor	Section C to D — Current in Amp.	Section C to D — Per Cent. Power Factor	Section D to E — Current in Amp.	Section D to E — Per Cent. Power Factor	Section E to F — Current in Amp.	Section E to F — Per Cent. Power Factor
B only	100.0	80.0	.....	....	.....	.....	.....	.....	.....	.....
B and *C* only	298.4	70.5	200.0	65.0	.....	.....	.....	.....	.....	.....
B, *C* and *D* only	394.0	76.2	294.3	74.7	100.0	90.0	.....	.....	.....	.....
B, *C*, *D* and *E* only	688.3	64.3	590.7	67.6	391.5	69.1	300	60	.....	.....
B, *C*, *D*, *E* and *F*	1017.8	96.5	954.9	98.3	810.0	99.97	*—720.2	*—99.96	*—600	*—90

* Leading currents and power factors are indicated by minus sign.

Whereas, induction machinery inherently causes a lagging of the current behind the circuit voltage, not all electrical equipment falls in this group. Some types of apparatus have practically no inductive effect upon its circuit, and the current that it takes is in phase with the voltage. This class of apparatus is called noninductive. The third class of equipment using elec-

trical energy takes a current from the main line which leads the voltage. Such is the distinguishing characteristic of a condenser. A long transmission line acts as a condenser in that it sometimes requires hundreds of amperes of charging current, leading the impressed voltage by an angle of nearly 90 degrees.

The current taken by a synchronous motor or a rotary converter may be made to lead the voltage by any desired amount. This condenser characteristic in causing a leading current to flow is now applied successfully

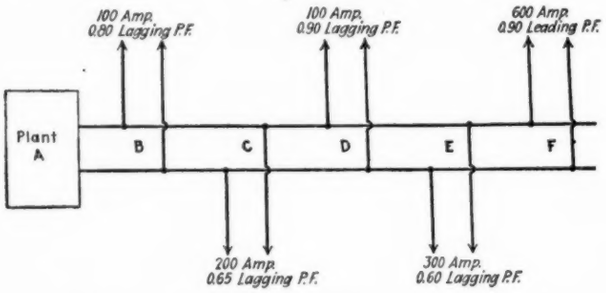


FIG. 2. LOAD DISTRIBUTION ON A CIRCUIT

in practice to correct for the large lagging currents caused by induction equipment. By applying a leading current of proper magnitude and phase, relative to the lagging current, the resultant current may be made to be in phase with the voltage so that the system operates at unity power factor. To illustrate this by example, consider a group of induction machinery taking 100 amperes, which lags the impressed voltage by 60 deg., which is equivalent to a power factor of 0.50. The condenser equipment must take a current of 100 amperes at a 60-deg. angle of lead in order to adjust for unit power factor in the system. The resultant current will be 100 amperes in phase with the voltage. The power delivered is 100 per cent. greater than before, for the same power lost in heating the transmission line and the voltage regulation for constant voltage impressed upon the line at the generator has been improved from 26.1 per cent. to 9.87 per cent.

Synchronous motors of very large capacity have been installed for no other purpose than to create this condenser characteristic and to correct for lagging power factor. When so operated without load, it is called a synchronous condenser. Machines of capacity ranging from 2000 to 3000 kv.-a. are commonly found in operation in the large systems where energy is transmitted over long distances, and machines as large as 15,000 kv.-a. have been installed. These units are capable of large capacity ratings at approximately zero power factor leading or lagging. Sometimes a lagging power-factor current component is required from the synchronous condenser in order to neutralize the effect of the leading-current characteristic of the charging current in a long, lightly loaded high-voltage transmission line

For every synchronous motor there is a certain value of field current for each load that will cause its load current to be in phase with the voltage. If the field current is increased above this value, the load current becomes leading in respect to the line voltage, and a decreased field strength causes a lagging current to flow. The least current taken from the line to operate the motor is at unity power factor, and this excitation is called "normal field current." When the excitation is decreased, the line current required to operate the motor not only becomes lagging, but, in order to supply the same kilowatt load, must be much greater in value. This is illustrated graphically in Fig. 1, where the normal excitation is indicated as 2.5 amperes. When the excitation is reduced to 2.0 amperes, the line current becomes 20 amperes and for 1.50 field amperes, the line current is 64 amperes. Also increased field current above normal gives rise to line current of rapidly increasing value with leading power factor, as shown by the curve *AB*. Therefore, it is evident that the magnitude and phase characteristic of the current of a synchronous motor may be varied at the will of the operator by changing the field current above or below normal.

The limitation to the amount of current that the synchronous motor may take from the line is imposed by the maximum safe heating allowable as in any electrical machine. Therefore, the use of the synchronous motor as a device to supply a leading current to neutralize the lagging current taken by induction machinery becomes evident at once.

Fig. 2 shows a plant *A* supplying loads placed at *B*, *C*, *D*, *E* and *F*. Table II, which is self-explanatory, gives the current in each part of the circuit and its power factor. The leading current taken by the synchronous motor placed at *F* is seen to have a most

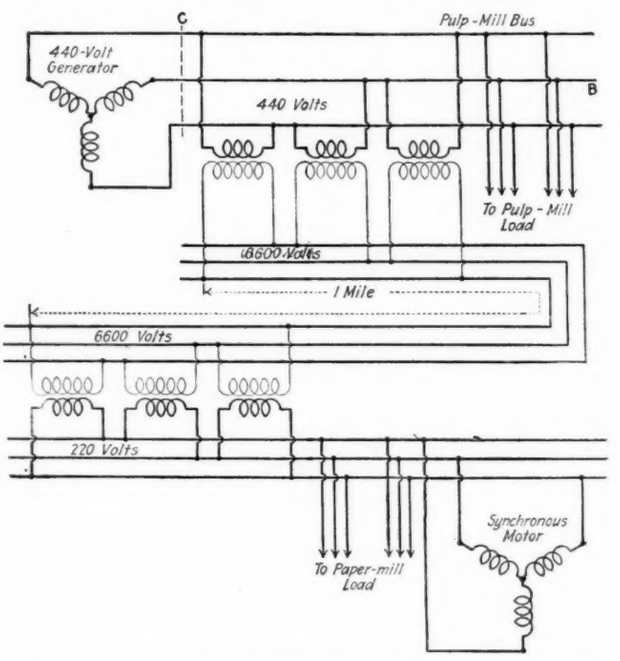


FIG. 3. PAPER- AND PULP-MILL LOAD DISTRIBUTION

beneficial effect upon the system by raising the power factor and rendering a more economical transmission of energy, superior voltage regulation with resulting satisfaction for operating conditions.

A synchronous motor located near the end of a transmission line may, by virtue of its leading current characteristic, raise the power factor at the distribution center of load from its previous low value, say 65 per cent. lagging, up to a value as high as 95 per cent. lagging or unity power factor, depending upon the kilovolt-ampere capacity of the motor relative to the amount of lagging component of the load.

Since the least amount of current is required for a given kilowatt load at unity power factor, the indications on the main ammeter are indicative of the approx-

imate position of unity power factor. By varying the motor excitation continuously in one direction (say increasing the excitation), if the main-line ammeter's indication steadily decreases to a minimum value and then begins to increase again, the power factor has been rising to unity after which the corrective leading current predominates in the system and the power factor becomes leading. The best method for power-factor indication is, of course, by the use of a power-factor meter. This instrument should be an indispensable adjunct to the system at any point of particular interest in regard to power factor.

Consider the problem involved in the following typical small system, Fig. 3. The synchronous motor is located at the end of the transmission line, in the paper mill, and may be used to raise the power factor of the paper-mill distributing system. The transmission losses will have been considerably reduced by this method, the generating system relieved of a large heating component and the voltage regulation at the paper mill materially benefited. The pulp-mill bus will have a power factor determined by the aggregate of all the machines operating therefrom. The power factor at the generating station will of course be lagging, since the combined lagging power factor of the pulp mill and the power factor of the paper mill, even though the latter be unity, must be less than 100 per cent.

Suppose that a synchronous motor were located at *B* instead of in the paper mill. The pulp-mill bus could have its power factor adjusted to unity. The paper mill would have a lagging power factor determined by the combined effect of its machinery. At the generating station the paper-mill current would combine with that of the pulp mill, the latter assumed to have unity power factor, and the resultant current from the generators would still be lagging, but with a value less than that of the paper-mill line. This position of the synchronous motor would be inferior to the first arrangement, since the line loss in transmission would not be reduced and the line regulation would not be benefited.

A synchronous motor located only at *C* could be so adjusted provided its capacity were sufficiently large that it would correct for the combined lagging current from both the paper mill and pulp mill. This would mean that the current flowing from *C* to the pulp mill would lag by an angle determined by its machinery and that flowing to the paper mill would lag by an angle determined by its machinery. However, the current at the generator would be in phase with the voltage. The generator would be working at high efficiency and good regulation, yet the same objection is present as in the case where the synchronous condenser was located at *B*. It does not aid in the efficient transmission of the energy.

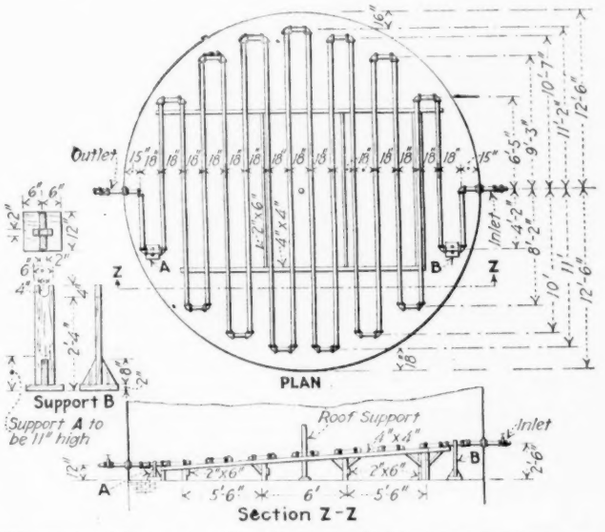
The ideal arrangement in this problem would be to have a synchronous motor located at each mill as in the position. These would correct the power factor of their respective lines and then the power factor at the generating plant would be practically 100 per cent., and the system would then be operating at its highest efficiency and with the best regulation for the given conditions.

Synchronous motors are being applied in practice not only for power-factor correction, but also for voltage regulation on long transmission lines. Either the natural line reactance or artificial reactors are located in the system, and by virtue of the leading or lagging current caused by the synchronous condenser the reactance voltage drop will either add to or subtract from the line voltage. The resultant voltage, therefore, may be kept within reasonably narrow limits by the inherent characteristic of the synchronous motor when floated on the line to maintain a constant voltage across its terminals and acts as a balancing medium to establish equilibrium of the phases in regard to both current and voltage in cases of unequal loading. It will take energy from the high-voltage phase or phases and supply energy to the lower-voltage phase, thereby automatically regulating for uniform voltage drop. Some notable installations are in operation where under the most severe load conditions the voltage regulation is maintained by this method within 2 per cent. plus or minus of the required voltage.

The application of synchronous condenser machinery has had such success in all of its installations that it has become a necessity in alternating-current plants where good regulation, reliability of service and general satisfaction are of primary importance. The results accomplished by way of regulation and power-factor adjustment, with synchronous motors are most interesting, and further developments are expanding the possibilities of their application.

Fuel-Oil Tank Heating Coil

The illustration shows the assembly and details of a heating coil for an upright steel fuel-oil tank as used



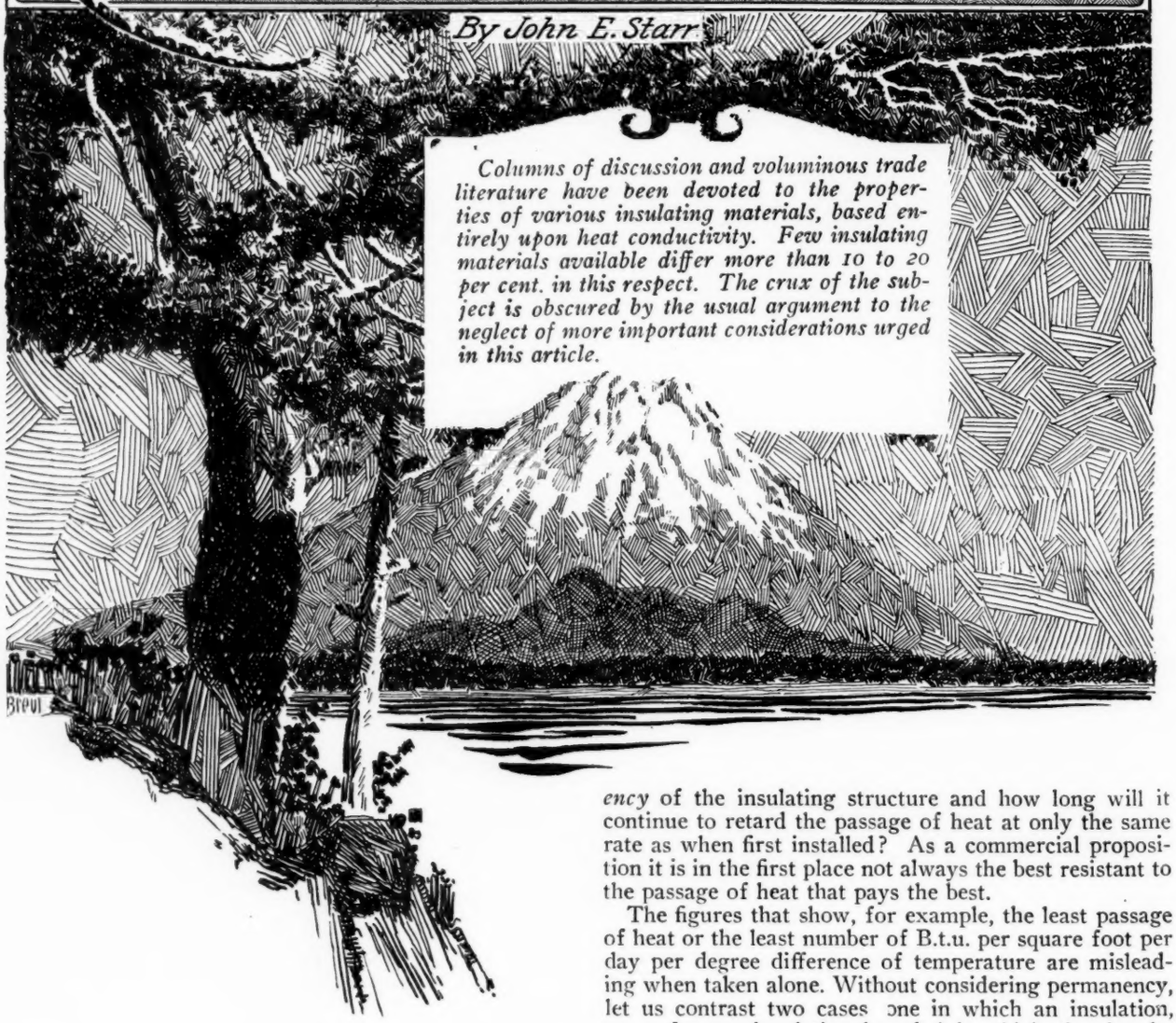
HEATING COIL AS USED IN UPRIGHT STEEL FUEL-OIL TANKS BY THE STANDARD OIL CO.

by the Standard Oil Co. The drawing will doubtless interest many who are now confronted with fuel-oil storage problems.

Where breaking of a piston ring caused a piece thereof to become lodged under a valve, resulting in the piston making a violent movement and causing injury to an employee, the employer is liable if it can be shown that the piston ring was badly worn before the accident and that the foreman in charge knew of that fact long enough to have permitted repair of the defect before the accident occurred. (Springfield, Mo., Court of Appeals, Yarborough vs. Wisconsin Lumber Co., 211 Southwestern Reporter, 713.)

PERMANENCY OF REFRIGERATION INSULATION

By John E. Starr



Columns of discussion and voluminous trade literature have been devoted to the properties of various insulating materials, based entirely upon heat conductivity. Few insulating materials available differ more than 10 to 20 per cent. in this respect. The crux of the subject is obscured by the usual argument to the neglect of more important considerations urged in this article.

REFRIGERATION is the process of taking away heat from a substance or an area which we desire to keep cool and putting the heat somewhere else. To reduce the amount of refrigeration or cost of taking away of heat, it is as a rule an advantage to surround that substance or area with a wall that has the property of retarding the passage of heat from the warm outside to the cool inside, so as to reduce the amount of heat to be taken away. As no substance or material entirely stops the flow of heat from a warm body to a cool one, the total line of calculation lies in balancing the cost to take away heat against the cost to retard the flow of heat. But the initial figures are not all there is to it.

The main question, after all, is, How long will the original figures, based solely on the passage of heat, hold good? Or, in other words, What is the *permanency* of the insulating structure and how long will it continue to retard the passage of heat at only the same rate as when first installed? As a commercial proposition it is in the first place not always the best resistant to the passage of heat that pays the best.

The figures that show, for example, the least passage of heat or the least number of B.t.u. per square foot per day per degree difference of temperature are misleading when taken alone. Without considering permanency, let us contrast two cases one in which an insulation, say, of some insulating board 4 in. thick showing by test a passage of 6.5 B.t.u. per day per square inch per degree of temperature difference, costing erected and faced 70c per sq. ft., 4 in. thick, and another showing 7.5 B.t.u. costing 60c. and assume that refrigeration costs for fuel 35c. per ton and in both cases 100,000 sq. ft. are involved, and that the average difference of temperature for the whole year is 50 deg., interest 6 per cent. (See Tables I and II.)

From this example it would appear that the insulation that passed more heat, or what usually is considered the poorest insulation, would be the better to buy as far as heat alone was concerned. But after all the main question is left unsettled by the figures given, and, of course, these figures are merely illustrative and might be modified by circumstances. The main question is: How long would the insulation continue to show these relative rates of the transmission of heat? If No. 2 transmits more heat per square foot as time passes, the original figures would manifestly be impaired.

*Consulting Engineer, New York City.

It needs little calculation to show that by the time No. 1 insulator depreciated only 5 per cent. as to heat conductivity and No. 2 depreciated 10 per cent, the figures would be reversed. So the most important item is that of depreciation, assuming that the insulating figures differ 15 per cent. or even 20 per cent.

Moisture the Principal Cause of Depreciation

Concentrating on the question of upkeep or durability, it may be said that the invasion of moisture—ever present in the atmosphere—is the principal cause of depreciation. Water is a better conductor of heat than most materials used in insulation; therefore, as the insulation becomes moist, its heat-conducting properties are increased.

Actual experiments on a 10-in. thickness have shown an increase of 25 per cent. from dry to slightly moist and 67 per cent. from dry to 30 per cent. moist. But the effect of moisture is also inimical to the insulation in addition to increasing its conductive property, especially in freezers.

TABLE I. COST OF INSTALLATION NO. 1, OR COST OF INSULATION

$0.70 \times 100{,}000$	= $70,000
$\frac{6.5}{4} \times 100{,}000$	= 162,500 B.t.u. per deg.
$162{,}500 \times 50$ deg. difference	= 8,125,000 B.t.u. per day
$\frac{8{,}125{,}000}{288{,}000}$	= 28 tons refrigeration per day
28×365 days	= 10,220 tons per year
10,220 tons at 35c cost per year to take up heat	$3,577.00
Interest on $70,000 at 6 per cent	4,200.00
Total cost, exclusive of upkeep per year	$7,777.00

TABLE II. COST OF NO. 2 INSTALLATION, OR POORER INSULATION

$0.60 \times 100{,}000$	= $60,000
$\frac{7.5}{4} \times 100{,}000$	= 187,500 B.t.u. per deg.
$187{,}500 \times 50$ deg. difference	= 9,375,000 B.t.u. per day
$\frac{9{,}375{,}000}{288{,}000}$	= 32.5 tons refrigeration per day
32.5 tons at 35c for 365 days	$4,151.87
Interest on $60,000 at 6 per cent	3,600.00
Total cost, exclusive of upkeep per year of poorest insulation	$7,751.87

Moisture, when it has once penetrated the insulation having a freezing side, is likely to stay there in large part and to freeze. The expansion of freezing to ice causes the water between the fibers or granules to expand and tear the latter apart and breaks the bond between them. Thus the structure of the material is broken down with the alternate freezing and thawing.

Many have observed this in the case of cork having one side exposed to atmospheric moisture and the other side below 32 deg. F. The granules become separated, and what was once a solid board becomes a mushy mass of wet granulated cork, to be removed best by a shovel, and of little value as an insulator. The same with fibers.

Testing by Soaking Not Conclusive

Testing the insulation by soaking for a day or two under water is not conclusive, for a structure so tested and showing light absorption will, after drying out, show on a weighing scale increase and decrease of weight when exposed to the ordinary atmosphere. Such increase and decrease following the curve of relative humidity of the air.

As much as 5 oz. of water to 1 sq. ft. of 2-in. thick insulation has been observed as an increase of water content in an insulating board during a change from 60 per cent. to 90 per cent. of relative humidity, this minimum to maximum change occurring in three days. Almost any piece of insulating board placed on a fine weighing scale becomes a good hygroscope, and relative humidity can be deduced from it with accuracy after the relation of its weight to humidity is once established and this at near the same temperatures.

How much more this effect of accretion of moisture may be when one side is cold and the other side warm can hardly be determined by experiment, as the protection offered by practical building walls can only be estimated.

It is submitted, however, that this test of hygroscopic effect is as valuable as a conduction test as an indication of the net value of an insulation against heat.

Moreover, a cold-storage warehouse breathes. That is to say, the pressures on the inside are above and below the pressures on the outside in a closed house, according to the changes in outside atmospheric pressure and inside changes of pressure due to opening of doors alternately collapsing and equalizing with the outside pressure. In warehouses using forced air distribution, the effect is noticeable. Three-tenths of an inch of water less pressure inside than outside in parts of the warehouse have been observed. Practical considerations would therefore argue for an equalizer of pressure, say in the shape of a small pipe from the closed inside room to the outside temperature.

Beneficial Effect of Pressure Equalizing Pipe

The loss of refrigeration by such an opening would be negligible, but the prevention of a pressure head against the entire surface and consequent forcing of moisture inward when the room "breathed in" would be eliminated. Also, any waterproofing of the outside wall or outside insulation is of value, as the moisture comes from the outside.

Waterproofing the wall or laying the insulating board in a good layer of hot asphalt or both are preferable to laying up in the more permeable cement mortar. Any attempt to render the insulator itself moisture proof is best of all, as it is almost impossible practically to render the armor invulnerable at all points. This latter work should be done even at some expense of reasonable conduction, considered alone.

We can standardize insulating value as far as transmission of heat is concerned, but until we can standardize upkeep we can never more than guess at the true commercial value of a heating-insulating structure.

Chart for the Determination of Circulating-Water Flow

By Edward S. Bristol

In the operation of a surface condenser it is often desirable to check up the circulating-water flow. For instance, the vacuum may fall off and it may at once be suspected that the circulating-water pump is not maintaining its normal discharge. The process of checking up the flow by calculation is not as familiar as some other computations that are more frequently employed in the power house. If the desired result could be obtained in an easy and convenient manner, it is believed that its value in condenser operation would be more fully appreciated. It was with this end in view that the accompanying chart was constructed.

The chart is intended for use with a generator unit, and for its use it is necessary to know only quantities that are ordinarily measured and recorded as part of the daily routine. These quantities and their values as used in the illustrative problem are as follows:

Steam pressure at throttle of main unit, 212 lb. per square inch gage.

Steam temperature at throttle of main unit, 427 deg. F.

Load on generator, 12,000 kw.

Condensate per hour, 170,000 lb.

Temperature of condensate, 97 deg. F.

Circulating water temperature rise, 5 deg. F.

The method of using these quantities in the chart is indicated by the dotted line. Taking the throttle steam pressure, 212 lb. per sq.in. gage, and temperature 427 deg. F., for the main unit a start is made in the upper left-hand section of the chart by finding the total heat in the steam at the throttle, 1222 B.t.u. per lb. This point is held while the main unit water rate is found in the upper right-hand section by locating the intersection of the steam consumption (condensate per hour), 170,000 lb. per hour, with the load on the generator, 12,000 kw. The water rate need not be read off (on the scale to the right) unless its value, 14.2 lb. per kw.hr., is desired, but should be carried over horizontally to an intersection with the solitary curved line sloping to the right. The point thus determined is carried down parallel to the lines labeled "water rate" until the previously found total heat in the steam is reached. From this point pass vertically downward to the temperature of the condensate, 97 deg. F., as given by the sloping lines in the lower right-hand section. From here proceed horizontally to the left to the circulating-water temperature rise, 5 deg. F., as given by the parallel lines sloping to the right. This point locates the number of pounds of circulating water per pound of condensate, 180, as given by the scale at the bottom. Proceed vertically from the last point to the pounds of condensate per hour, 170,000, as given by the lines radiating from the upper left-hand corner. This intersection locates the desired circulating-water flow, 61,400 gal. per min., as given by the scale on the left.

The chart is based on the equation,

$$W = \frac{C\left[H_s - \dfrac{3628}{W.R.}\right] - (t_c - 32)}{500\,(t_o - t_i)}$$

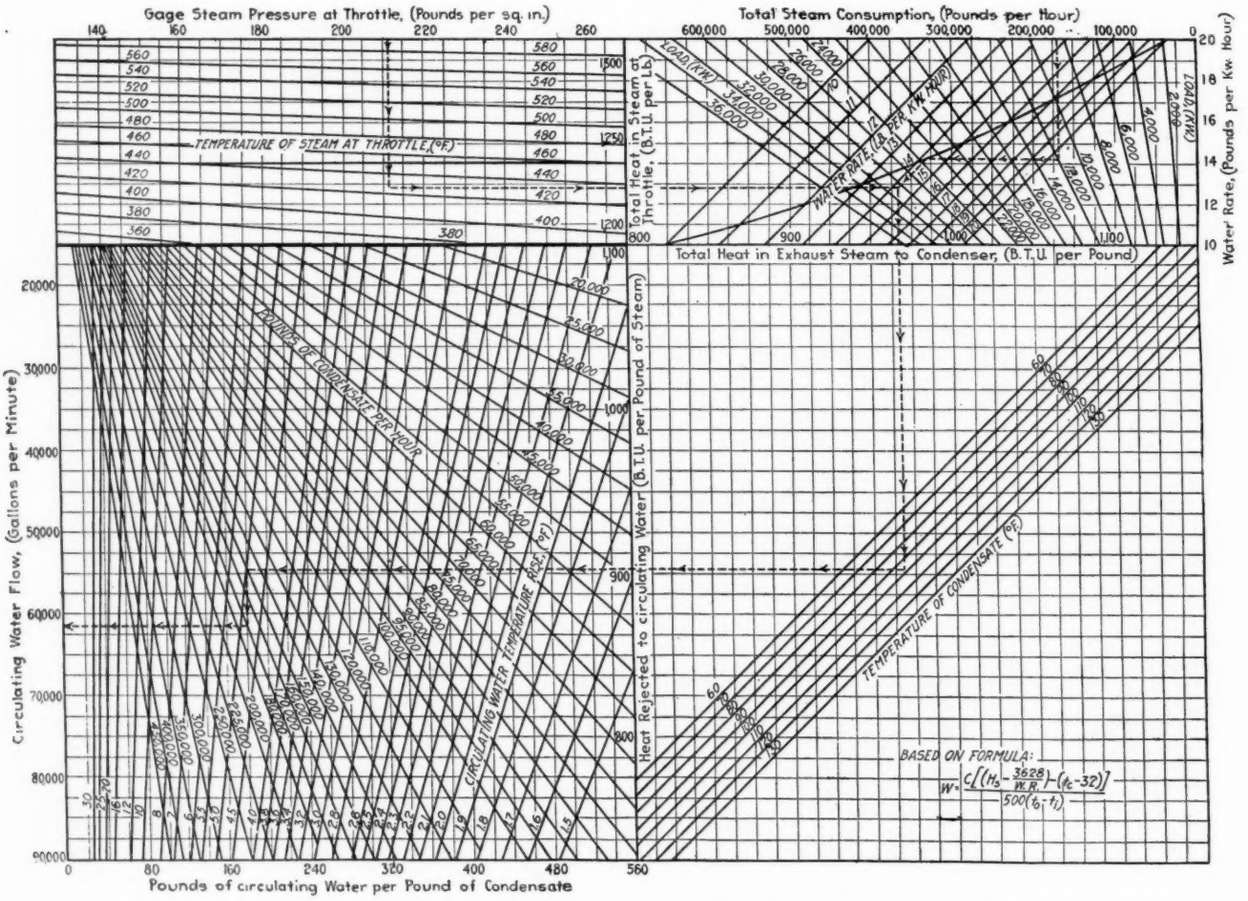

Gage Steam Pressure at Throttle, (Pounds per sq. in.)
Total Steam Consumption, (Pounds per Hour)
TEMPERATURE OF STEAM AT THROTTLE, (°F)
Total Heat in Steam at Throttle, (B.T.U. per Lb.)
Water Rate, (Pounds per Kw Hour)
Total Heat in Exhaust Steam to Condenser, (B.T.U. per Pound)
Circulating Water Flow, (Gallons per Minute)
POUNDS OF CONDENSATE PER HOUR
CIRCULATING WATER TEMPERATURE RISE, (°F)
Heat Rejected to circulating Water (B.T.U. per Pound of Steam)
TEMPERATURE OF CONDENSATE (°F)
BASED ON FORMULA:
Pounds of circulating Water per Pound of Condensate

CHART FOR THE DETERMINATION OF CIRCULATING WATER FLOW

where

W = Circulating-water flow in gallons per minute;

C = Pounds of condensate per hour;

H_s = Total heat in the steam at the throttle, B. t. u. per pound.

$W.R.$ = Water rate, pounds per kilowatt-hour;

t_c = Condensate temperature, degrees F.;

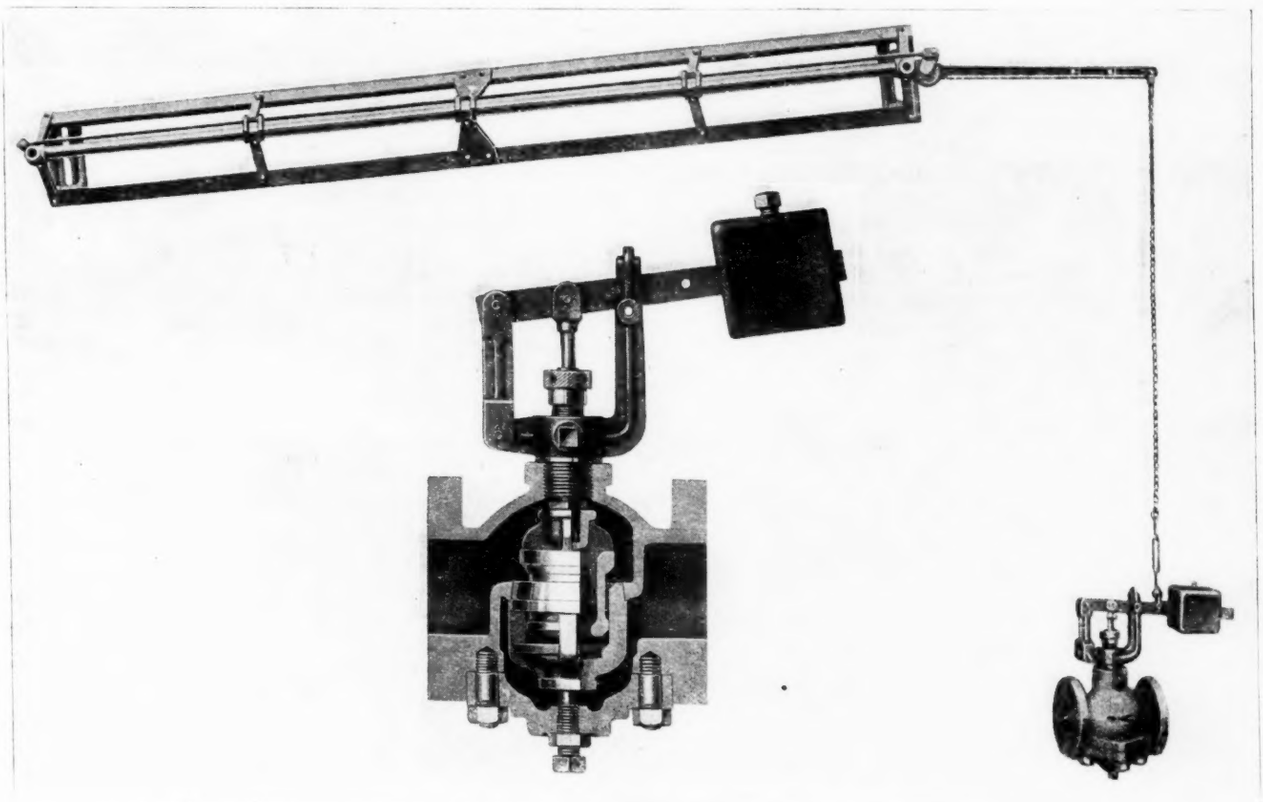
t_o = Circulating water outlet temperature, degrees F.;

t_i = Circulating water inlet temperature, degrees F.

The figure 3628 is the heat equivalent of 1 kw.-hr. (3412 B.t.u.) divided by 0.94 to allow for a 6 per cent. friction and radiation loss in the generator. To reduce the circulating-water flow from pounds per hour to gallons per minute the figure 500 is introduced.

McDonough Single-Tube Feed Water Regulator

A thermostatically controlled feed-water regulator has been perfected by the McDonough Automatic Regulator Co., Detroit, Mich. As is shown in the illustrations, it is of simple and strong construction and positive in action, with a lever ratio designed to insure prompt operation of the feed valve. The center of the copper expansion tube is rigidly stayed to a steel framework which permits the expansion or contraction of the tube in either direction from the center through the flexible supports to which it is connected. Along the length of the tube are supports that will allow movement in a longitudinal direction, but prevent sidewise or vertical buckling.



McDONOUGH SINGLE-TUBE FEED-WATER REGULATOR AND SECTION OF FEED VALVE

At the lower end the thermostatic tube is connected below the water level of the boiler and the upper end to the steam space, the slope of the tube determining the limits of action. Bolts in radial slots at either end of the regulator permit an additional incline or decline after the device has been installed. The operating lever can be attached to either the water or the steam end of the tube and can be adjusted to meet plant conditions.

The action of the tube operating the lever depends upon the changing water level in the boiler and the amount of steam or water entering the expansion tube.

The convenient features of the feed valve are shown in the sectional view. Whether of the beveled-seat or balanced type, it is placed within a cage and can be quickly inserted or removed by hand through a flanged opening covered by a plate bolted to the bottom of the valve body. As a consequence it is not necessary to remove the valve body from the pipe line or to disturb the bonnet or working parts for examination or regrinding of the valve parts.

The valve stem is connected to the valve-operating lever by a clamp yoke which permits the stem being disconnected for the removal of the valve and stem. A swivel connection is provided at the lower end of the stem to allow the valve to properly adjust itself to the seats in the valve cage.

Another feature is that the yoke of the valve is of swivel construction so that it can be turned around in any position and locked to the bonnet by a setscrew. This is often desirable when lining up the lever of the valve with the lever connected to the thermostatic tube.

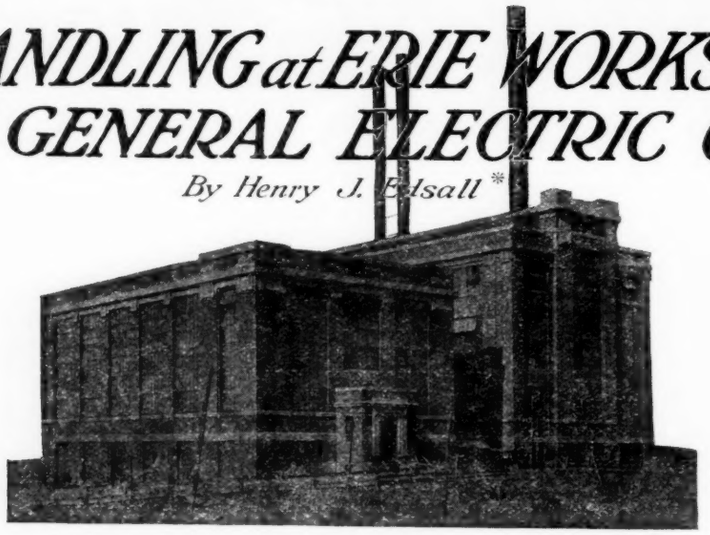
It will be noticed that the counterweight on the valve-stem lever is adjustable and is secured at the desired position by means of a setscrew. Its function is to partly or fully close the valve as the water level rises.

By means of a chain a steel pin is connected to the yoke for the turning of the packing nut or to hold the valve in an open position by the insertion of the pin in the hole in the guide arm of the yoke when refilling a cold boiler.

As the water falls or rises in the boiler, it correspondingly falls or rises in the thermostatic tube, with a corresponding increase or decrease of the length of the tube occupied by the steam, causing it to expand or contract to regulate the opening of the feed valve and admit the proper amount of water to the boiler. In this way a constant feed to the boiler in proportion to the demand is obtained and the high efficiency of a practically constant water level insured.

COAL-HANDLING at ERIE WORKS PLANT OF GENERAL ELECTRIC CO.

By Henry J. Edsall *



MODERN power plants have become more or less standardized in both building and equipment but this does not, of course, mean that they are all built alike. Conditions and requirements vary, and engineering opinions also still differ as to the most suitable types of buildings to be used for boiler and generator rooms, the location of generator room in relation to the boiler room, types and arrangement of coal- and ash-handling equipment, stokers, stacks, steam piping, flues, etc. The generator-room equipment is settled down to more definite standards than the boiler-room equipment, and the building required to house this equipment is of a comparatively simple type. The shape of the boiler-room building, however, depends largely upon the type of coal-and ash-handling equipment to be used, the arrangement of the boilers and steam piping, the location of economizers, if used, and the arrangement of the stacks and flues. There are various combinations possible, and while certain arrangements are considered more or less standard, these are not always adhered to.

The design of the new power plant of the General Electric Co. at Erie, Penn., was developed under the direction of August H. Kruesi, engineer of the Construction Engineering Department, and it is unique in a number of features. One feature that has been given special attention is future development, and the boiler room as built at present is only one-fourth the ultimate size. The design, therefore, was arranged for the present requirements and also for flexibility and low cost of future extensions.

Ample light for the operating space in front of the boilers has been obtained by facing them toward the outside wall of the building and providing a generous supply of windows in this wall, Fig. 1. The boilers will also face toward the light in future extensions. Ventilation has been provided for by ventilators in the front windows and in the monitor overhead.

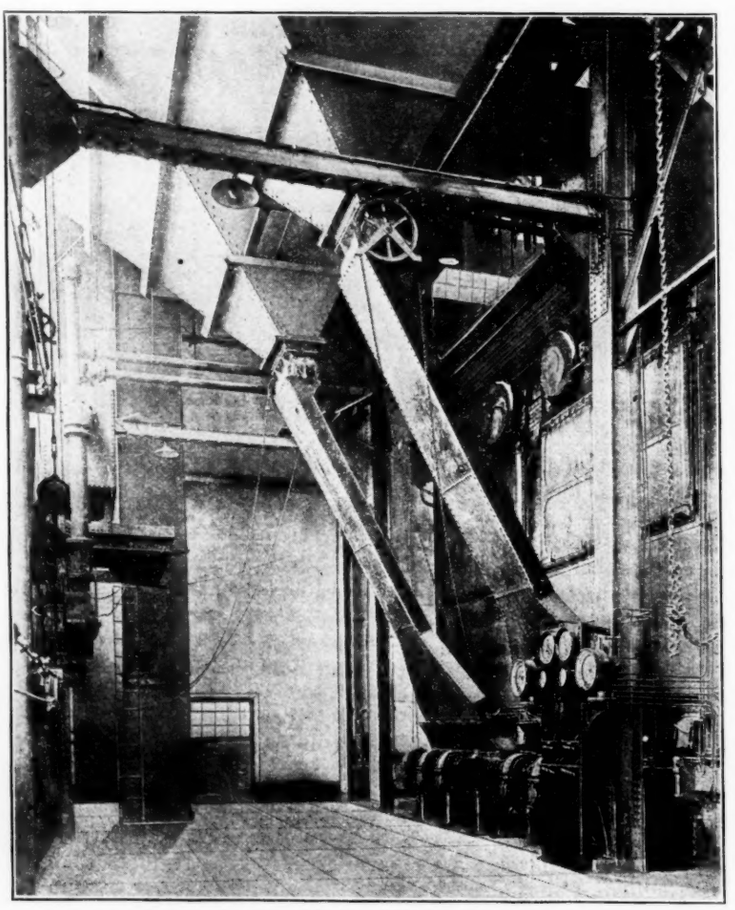


FIG. 1. PART OF OVERHEAD BIN AND SPOUTS TO STOKERS, WITH COAL ELEVATOR IN BACKGROUND

The coal-handling equipment includes overhead bin over the space in front of the boilers, with spouts direct to the stoker magazines, the overhead bin capacity being sufficient to run the plant for about two days. In addition there is a reserve coal storage which, instead of being placed outside the building, is located in the basement of the building and unloaded into a storage space underneath the tracks. This necessitates a deep basement, but makes it possible to do all the unloading under cover, therefore there are fewer chances for delays or a coal shortage, as frozen cars of coal can be run into the basement and allowed to stand long enough to thaw out

*Engineer with Link-Belt Company.

before they are unloaded. This feature is a decided advantage where the winters are severe.

For elevating the coal and distributing it in the overhead bin, standard chain and bucket elevators and rubber-belt conveyors were selected. These machines made a comparatively simple design possible for the present boiler room, and also provided for the future extensions with as little additional expense as possible. Only coal is handled by the conveyors, the ashes being dumped from the ashpits under the stokers into railroad cars standing on the tracks in the basement of the building.

The present boiler room contains six 600-hp. Babcock & Wilcox boilers, four of which are equipped with Taylor stokers and two with Riley stokers. The boilers are set in a single row in batteries of two. Each battery occupies a space of about 30 ft., with spaces between the batteries of 10 ft. center to center of columns, and similar spaces at the ends, so that the total length of the present building, center to center of the columns, is 130 ft. Space for economizers is provided over the boilers. Three railroad tracks are run into the building on a level 28 ft. below the operating flood, and underneath the railroad tracks is the reserve cold-storage space, the bottom of which is 23 ft. below the track level or 51 ft. below the operating-floor level.

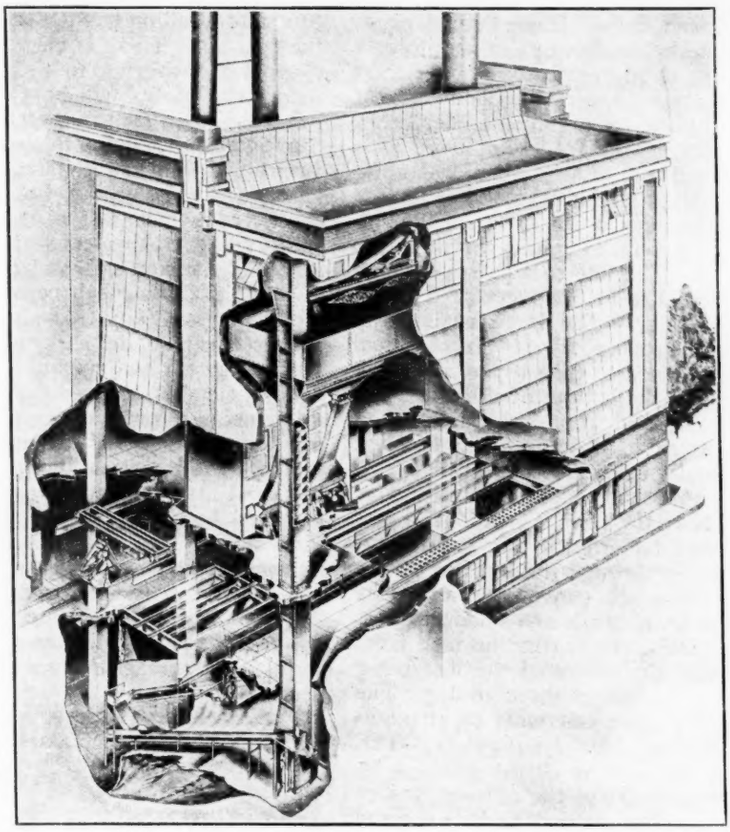


FIG. 2. GENERAL ARRANGEMENT OF BOILER ROOM

The track hopper for feeding coal to the conveyor system is located underneath the center track and the outside tracks run underneath the present and future ash hoppers. Fig. 2 shows the general arrangement of the boiler room.

The present boiler room has been built with one temporary side wall and one temporary end wall, and the first extension contemplated is to double the width of the present boiler room and put in an additional row of boilers, facing in the opposite direction, toward the future outside wall. The additional extensions will be to double the length of the boiler room, either doing one side first and then the other or both together, according to requirements. The generator room is placed alongside the boiler room and has one temporary end wall so that it can be extended to double the length in the future, this being the ultimate size of the generator room as planned.

The track hopper is underneath the center track near the temporary end of the boiler room, and when this room is extended the full length it will be near the center of the building. This track hopper is unusually large, the length being 28 ft. so as to take in all the hoppers of the largest railroad cars without moving them, and the width being over 20 ft. so as to provide for two

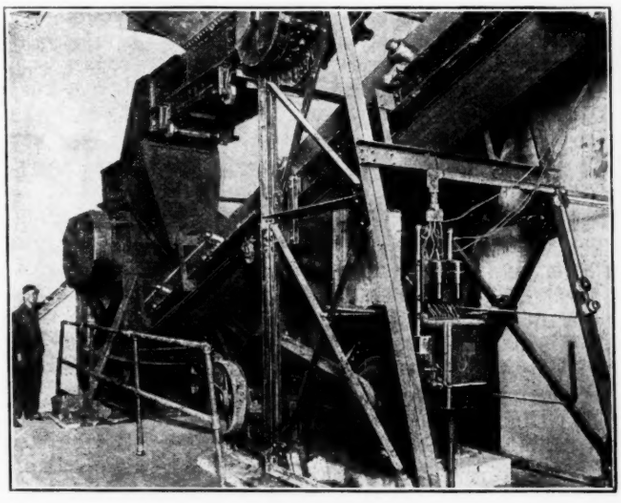


FIG. 3. FEEDER AND CRUSHER UNDERNEATH TRACK HOPPER AND BELT CONVEYOR No. 1

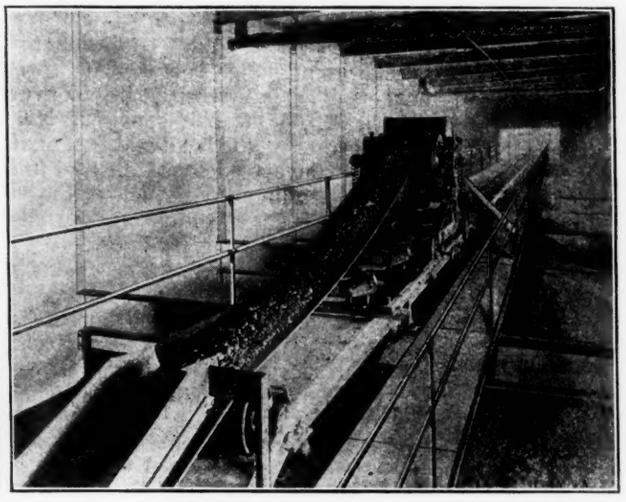


FIG. 4. DISTRIBUTING BELT CONVEYOR DELIVERING TO OVERHEAD BIN

feeders underneath. The track is supported over the hopper on 15-in. girder beams, framed into heavy girders. The hopper itself is made of ⅜-in. steel plates, stiffened by angle irons. Underneath the hopper there is a standard reciprocating feeder below one of the hopper openings, and a place for a future feeder below the other hopper opening. This feeder is 30 in. wide by 10 ft. long and feeds the run-of-mine coal automatically to a chute leading to the crusher. The bottom of the chute is fitted with a screen plate of the lip-screen type with openings 6 in. long and varying from 1 in. to 1¼ in. in width. The fine coal passes through this screen and is delivered to belt conveyor No. 1, located underneath the feeder. The large coal passes on down the chute to the crusher, Fig. 4. In case coal that has already been screened to the proper size is received, the screen plate on the bottom of the chute can be raised so as to allow all coal to pass through to belt conveyor No. 1 without any of it going to the crusher.

The crusher is a standard 30x30-in. two-roll spring relief machine, and it is supported on a steel frame about 6 ft. 4 in. high above the floor. The foot of belt conveyor No. 1 is located underneath this steel frame so that the coal that passes through the crusher can be delivered to the belt. This belt conveyor runs in the same direction as the railroad track and underneath it, but a little to one sde of the center, the distance from the center of the track to the center of the belt being about 4 ft. It is set at an incline of about 18 deg. The belt is a 24-in. four-ply rubber belt with ⅛-in. additional rubber on the carrying side. Its speed is 200 ft. per minute.

A 35-hp. 900 r.p.m. motor drives the crusher, feeder and belt conveyor No. 1. The connection between the motor and the jackshaft is by means of silent chain; from the jackshaft to the crusher a 12-in. six-ply belt drive; and there are belt drives from the jackshaft to a spur-geared countershaft of the belt conveyor No. 1 and to a countershaft which is spur-geared to the eccentric shaft of the reciprocating feeder. The future installation will include duplicates of the feeder, crusher and belt conveyor No. 1 with the necessary driving machinery.

Belt conveyor No. 1 and the future duplicate belt deliver the coal to a set of chutes arranged with flap gates in such a manner that the coal from either of these two belts can be delivered to either one of two other belts running at right angles, one of these belts running over to an elevator close beside the wall of the first boiler room, and the other one of which will run over to an elevator in the future extension to be built alongside the present boiler room. The former belt which is now installed is known as belt conveyor No. 2, and is the same type as belt conveyor No. 1. The length, center to center of the head and foot shafts, is 55 ft. 8 in. This belt conveyor delivers the coal to the elevator boot on the ascending side which is the side toward the wall. Both belt conveyors are supported on steel framework, bolted to the concrete floor.

The elevator is 94 ft. 6 in. centers. The chains are 18-in. pitch steel strap, steel bushed, roller chains with 4 in. diameter rollers at the joints. The buckets are 17⅝x10x16 in., and they are riveted to the chain links. The elevator is inclosed in a No. 10 steel casing, properly braced and stiffened, and the chains are guided throughout the ascending and descending runs by double 6-in. channels, riveted to the inside of the casing. The casing is wider at the top and bottom where the buckets pass around the head and foot wheels, and in between these points the chains are brought closer together by means of the guides so that the casing need not be made so large. The coal is delivered at the head to a chute leading to the distributing belt conveyor over the coal bin. There is also a gate in the bottom of the chute for delivering to the bin at this point. In the future the chutes will be arranged so the coal can be delivered to either the present distributing conveyor, or the future one running in the opposite direction over the future coal bin in the extended boiler room. The elevator is driven by a 20-hp. 900-r.p.m. motor which is connected by means of a silent chain to the first countershaft, and then by means of two pairs of spur gears to a second countershaft and the head shaft respectively.

The distributing belt conveyor, Fig. 4, over the coal bin employs a 20-in. four-ply belt, with ⅛-in. additional rubber cover on the carrying side. This belt is about 105 ft. centers and runs at a speed of 200 ft. per min. The foot end is dropped down somewhat so as to bring it low enough for receiving coal from the elevator without the necessity of extending the elevator through the roof. The coal is discharged on both sides of this belt, and at any point along the length by means of a standard belt conveyor tripper running on T-rails on each side of the belt, this tripper being propelled in either direction by means of power obtained from the belt itself. This conveyor is driven by a 7½-hp. 900-r.p.m. motor, the connection between the motor and the countershaft being by a silent chain, the countershaft being spur-geared to the drive shaft of the conveyor.

The machinery is designed for a capacity of 85 tons per hour, and all details are of the latest and most improved design.

Testing Vacuum Pumps

By William D. Taylor

In power-plant practice it is advisable to check up the performance of the vacuum pumps frequently to see if they are capable of handling the amount of air for which they were designed. This applies particularly to the turbo-vacuum pumps, as the erosion of the runner

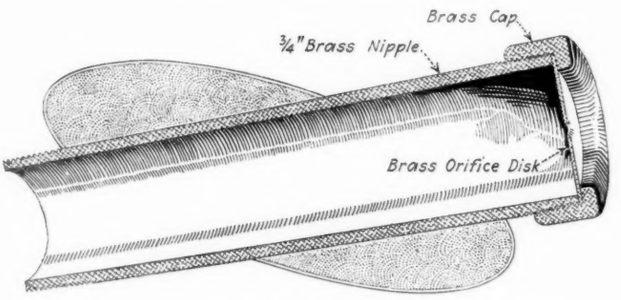


FIG. 1. ORIFICE FOR TESTING VACUUM PUMPS

blades impairs their efficiency, gradually lessening the amount of air the pumps will handle. With reciprocating pumps the test will determine the condition of the valves, glands, etc. In either case the comparison of a standard curve for first-class conditions with one obtained by test at any time, will show the ability of the pump to handle the air in the condenser and still maintain the vacuum desired.

The method here described is by means of standard calibrated air nozzles, "or educated air holes." A series of brass disks about $\frac{1}{16}$ in. thick and 1 in. in diameter, having holes varying from ⅛ to about ¾ in. in diameter, are used to determine the amount of air being admitted. The holes are bored accurately to size, with the edge on

one side rounded so as to form a bell-mouth orifice. The inner edge should be sharp.

The apparatus consists of a ¾-in. brass nipple, as shown in Fig. 1, about 3 in. long, having a ¾-in. pipe thread on both ends, a brass cap, threaded, to go on one end of the nipple and having the largest orifice in it, about ¾ in., with a well-rounded bell mouth; and a series of brass disks, having bell-mouth orifices ⅛ in. up to ⅝ in., and which can be put in between the nipple and the cap for any size orifice desired during the test.

Preparations for the test consist in making a ¼-in. connection for a mercury column to read the vacuum, and placing a ¾-in. nipple and gate valve into the air line close to the pump for the calibrated orifice. These two connections for the orifice and mercury column must be between the pump and the valve separating the pump from the condenser, as this valve must be closed during the test.

Readings are taken of the size of orifice, vacuum obtained, temperature of the air in the room, temperature of the hurling water in the case of turbo-vacuum pumps and the barometer. Usually, the temperature of air and hurling water and the height of the barometer need be read only once for each run.

The temperature of the hurling water determines the maximum vacuum obtainable. The barometer is read so as to refer all vacuum readings to a 30-in. barometer.

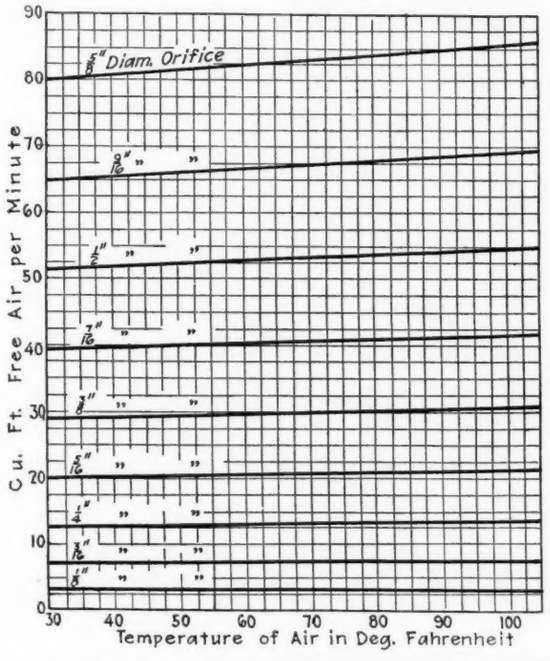


FIG. 2. VOLUME OF AIR FLOWING THROUGH ORIFICE TO VACUUM PUMP

Flieguer's formula for the flow of air through orifices may be used to calculate the amount of air handled. This formula is usually expressed as follows:

$$W = 0.530\, F \frac{P}{\sqrt{T}}$$

where

W = Weight of air per second;
F = Area of the orifice in square inches;
P = Pressure on orifice in pounds per square inch;
T = Absolute temperature in Fahrenheit degrees.

Now the volume of one pound of air is equal to $0.3704 \frac{T}{P}$, using the same notation. Combining this the equation we get $Q = 0.1964\, F \sqrt{T}$, where Q = cubic feet of air per second. Multiplying by 60 to reduce the answer to minutes instead of seconds, $Q = 11.78\, F \sqrt{T}$, where Q = cubic feet of air per minute.

In using this equation it should be remembered that the absolute temperature T is equal to the temperature as read on the Fahrenheit thermometer, plus 460 deg. It must be remembered also that the value of Q given is the volume of air, at atmospheric pressure and temperature, which is flowing through the orifice per minute.

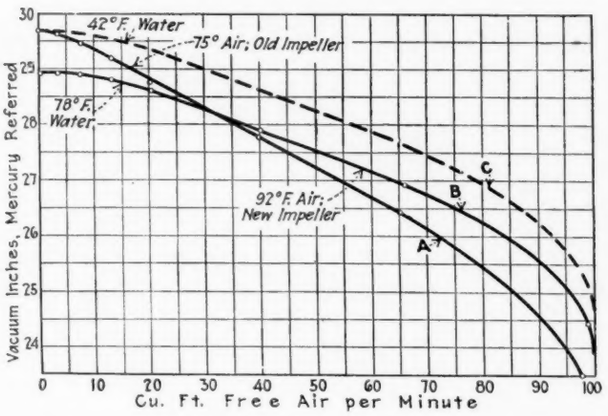


FIG. 3. PERFORMANCE CURVES OF VACUUM PUMPS

The only quantities that have to be determined, then, are the area of the orifice in square inches and the temperature of the air in degrees F. For example, assume the temperature of the air at 75 deg. F. and that the orifice having a ⅛-in. hole was used. The area F would be 0.01227 sq. in., and the value of T would be $75 + 460 = 535$. Then the volume of free air going to the pump would be $11.78 \times 0.01227 \times \sqrt{535} = 3.34$ cu. ft. per minute.

As Fliequers' formula is based on theoretical considerations, it will probably give a value a little too large. A great number of experiments, however, have shown that the error is very slight, so for most work it may be used without modification. For very accurate work the particular orifice used should be calibrated under conditions corresponding to those under which it will be used.

In using the formula the back pressure on the orifice must be less than 52.7 per cent. of the atmospheric pressure. If the back pressure is greater than this value, another and more complicated formula must be used. This latter formula has the further disadvantage of being less accurate.

The curves shown in Fig. 2 give the discharge in cubic feet per minute for various temperatures for each size nozzle. By using this curve sheet it is not necessary to do any computing at all.

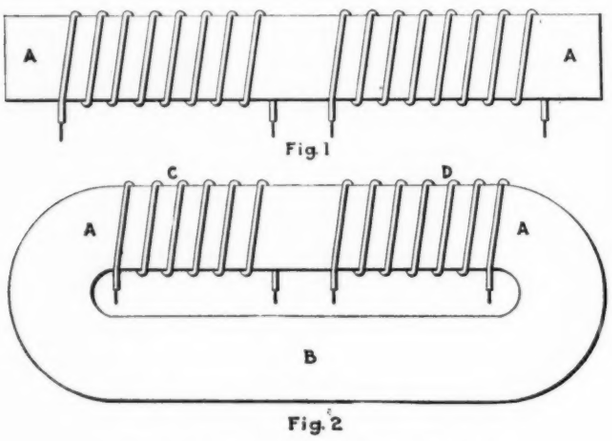
Fig. 3 shows results obtained before and after changing the runner in a centrifugal vacuum pump. This also illustrates the effect of the temperature of the hurling water upon the vacuum. The first test was taken with water at 42 deg. F., the second at 78 deg. This gives a vacuum about 0.7 in. Hg. lower for the higher temperature water.

The shapes of the curves A and B show the improvement made by renewing the runner in this pump. A test taken at the same temperature of hurling water, 42 deg. F., would probably take the shape indicated by the dotted curve C.

The Electrical Study Course—Construction and Operation of Transformers

The construction of the transformer is described. How eddy currents are induced in the core and how these currents are eliminated is explained.

IN THE last lesson it was shown that when two coils are mounted on a single iron core, as in Fig. 1, an alternating voltage applied to one of them will cause a similar voltage to appear across the ends of the other, even though no electrical connection exists between the two coils. Such a device is known as a transformer. In practice the core *A* is extended and bent around to form a complete loop of iron as in Fig. 2. To prevent wasting the part *B* of the core, the coils are distributed over it as well as over *A*. Moreover, it has been found that better operating results are obtained when one coil is wound over the other, instead of side by side. The result is that in actual transformer construction the coils would be placed somewhat as illustrated in Fig. 3.



FIGS. 1 AND 2. COILS ON IRON CORE

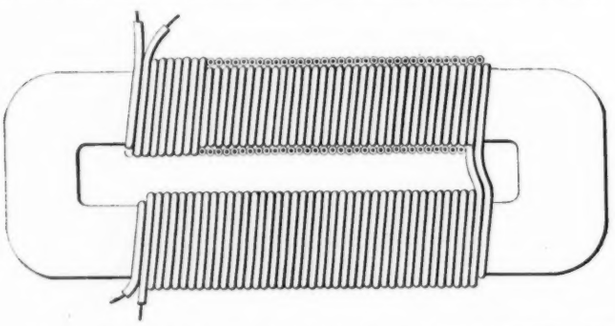
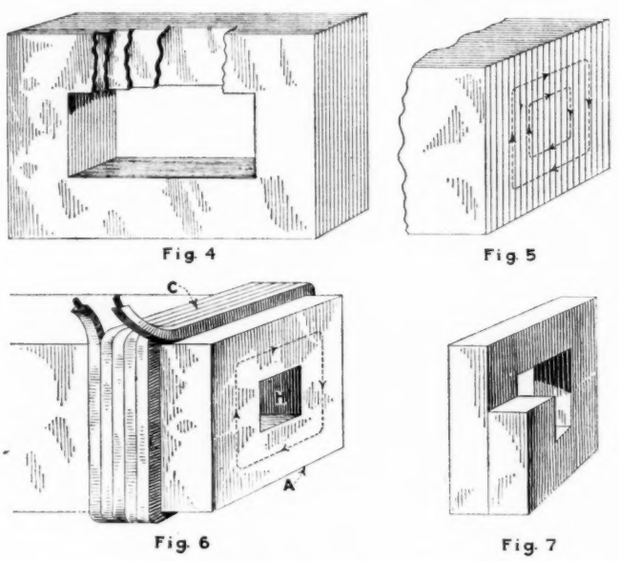


FIG. 3. TWO COILS, ONE WOUND OVER THE OTHER, ON AN IRON CORE

The iron core is not made of a single piece of solid iron bent into shape, as indicated in Figs. 2 and 3. Instead, it is built up out of many pieces of sheet iron that are stamped to the shape of the core, so that the core would actually have a structure such as that illustrated in Fig. 4. The object of this is to reduce to as small a value as possible the currents that are induced in the core, known as eddy currents. Consider a solid core with a hole *H* in it, as in Fig. 6. The shaded section comprises a complete circuit, as indicated by the arrows. It is therefore equivalent to a conductor making a single turn, whose ends are joined, as in Fig. 7. Therefore, if an alternating current flows in coil *C*, Fig. 6, it will induce a voltage in the core *A*, the same as in a turn of any other conductor. Since this single turn is closed upon itself, a current would flow through it. The hole *H* in Fig. 6 may be imagined to be made smaller and smaller, until it closed and made a solid core; however, the eddy currents would still circulate. If the core is built up of sheets of iron, as in Fig. 5, it is evident that the eddy currents in circulating around in the core must cross from one sheet to another, as indicated by the dotted lines. The resistance introduced in the path of the current by the slight air space that may be between the sheets and by the thin coating of scale on their surfaces, is sufficient to restrict the flow of current to comparatively small values, whereas the solid core will allow them to assume values that involve large losses. For simplicity of construction, the individual sheets of iron are not punched out as a complete loop, as in Fig. 8, but in one type of construction they are made in two pieces, as in Fig. 9, and assembled in two parts, as in Fig. 10. The coils—which are wound on forms—can then readily be slipped over the two parts of the core, which are then dovetailed together to form a complete circuit of iron. The appearance of a core and its coils is shown in Fig. 11.



FIGS. 4 TO 7. REPRESENT HOW EDDY CURRENTS ARE GENERATED IN AN IRON CORE

The volage induced in coil *D* of Fig. 2 when coil *C* is connected to a source of alternating current, is proportional to the number of turns in the coil. This must be so, since the voltage in *D* is induced by the lines of force which cut across its turns as the lines expand outward and collapse with each alternation of the current in *C*.

It is evident that the magnetic flux will induce the same voltage in each turn of the conductor it cuts, and since the total voltage of the coil is the sum of the voltages induced in its turns, it follows that the greater the number of turns, the greater must be the voltage of the coil, and vice versa. It is this fact which makes it possible to step up and step down voltages. Thus, if coil D, Fig. 2, has 100 turns and the voltage induced in it is 220 volts, we could get 2200 volts by substituting a coil of 1000 turns for D and leaving C the same as it is. Not only is the voltage of D proportional to the turns in it, but its voltage and that applied to C are in the ratio of the turns in D and C. Thus, if C has 12,000 turns and D has 200, and 6600 volts is applied to C, the voltage across D will be 110 volts, because, volts D : volts C :: 200 : 12,000, or volts $D = \frac{\text{volts } C \times 200}{12{,}000} = \frac{6600 \times 200}{12{,}000} = 110$ volts. This is readily explainable since the voltage applied to C makes a certain current flow through it. This current creates a magnetic flux which will produce in every turn of D the same voltage as exists across each turn of C.

The winding to which the source of current is applied is called the primary of the transformer. The winding

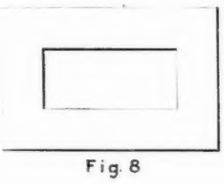


Fig. 8

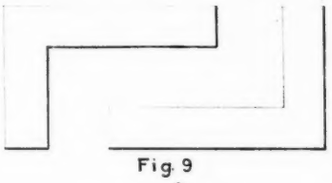


Fig. 9

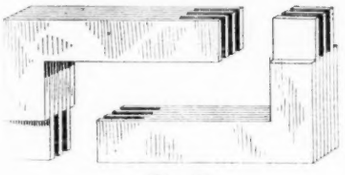


Fig. 10

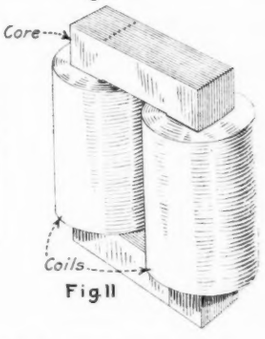


Fig. 11

FIGS. 8 TO 11. CONSTRUCTION OF CORE AND COILS

in which a voltage is induced is called the secondary. If the secondary voltage is higher than the primary, the transformer is referred to as a step-up transformer; if the secondary voltage is lower than that of the primary, it is a step-down transformer. Whether it be one or the other, we have the relation, secondary voltage : primary voltage :: secondary turns : primary turns. If we substitute the quantities by symbols we have, $E_s : E_p = T_s : T_p$, where E stands for voltage and T for turns.

We now come to that property of transformers, the possession of which makes possible their use for power-transmission purposes, which is, that the current taken by the primary is automatically controlled by the load that is connected across the secondary. In Fig. 12 P is the primary and S the secondary windings of a transformer.

How the primary current responds to the secondary load and adjusts itself to the value of the latter may be explained as follows:

The moment current begins to flow through S, Fig. 12, the flux in the core T will be affected by it. The magnetomotive force set up by the current through S will always be in opposition to that created by the current through P. For example, if at a given instant, a is positive and b negative, the current through P will be in the direction of the arrows, making the direction of the flux that indicated by the arrowheads on the broken lines representing the lines of force. The voltage induced in S will consequently be in the direction of the arrows on

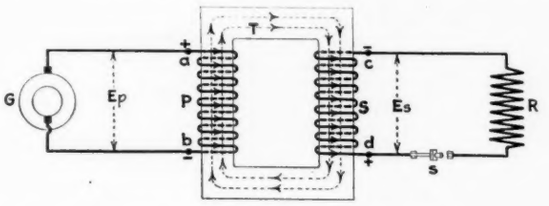


FIG. 12. SCHEMATIC DIAGRAM OF SIMPLE TRANSFORMER

winding S, and the flow of the current will therefore also be in that direction if switch S is closed. The magnetomotive force set up by this current will tend to set up a flux through coil S, and hence will be opposed to that due to P. The result is that the reactance of P is lowered, since all reactance is due to the fact that flux is continually cutting back and forth across the conductors of which the reactance is composed. As soon as the reactance is thus reduced the current through P increases, until the flux through T is again the same as before. When the current in S is reduced by a change in its load, less flux is developed by it, so that there is less flux to oppose that of P. This causes the flux through T to increase, thereby increasing the reactance of P and consequently throttling the current through it to the point where the flux through T again becomes normal.

The problem in the previous lesson was to find the kilovolt-ampere load and the current per terminal of a balanced three-phase system supplying 75 kw. at 0.65 power factor; the volts between terminals being 2300. Kilovolt-amperes, $kv.\text{-}a. = \frac{kw.}{P.F.} = \frac{75}{0.65} = 115$. The

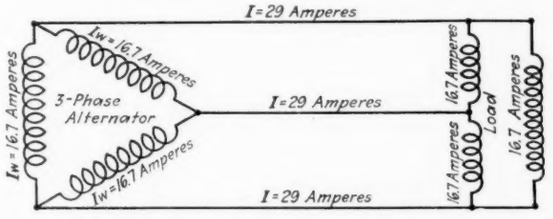
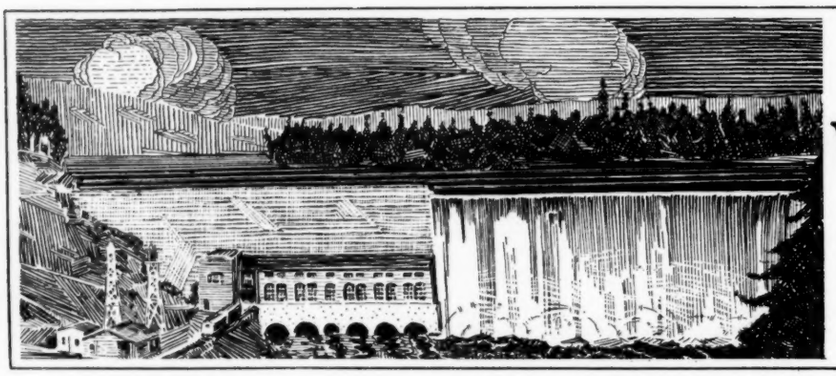


FIG. 13. DIAGRAM OF A THREE-PHASE CIRCUIT

current per terminal in a balanced three-phase system is, $I = \frac{kv.\text{-}a. \times 1000}{E \times 1.73}$, where E is the voltage between terminals, then $I = \frac{115 \times 1000}{2300 \times 1.73} = 29$ amperes. It was also required to find the current in each of the generator windings if they were connected in delta, as in Fig. 13. In a delta-connected winding where the system is balanced, the current, I_w is equal to the current per terminal $I \div 1.73$, or in this problem $I_w = \frac{I}{1.73} = \frac{29}{1.73} =$ 16.7, as indicated in the figure. This is also the current flowing through each load.



POP'S WATER-POWER COURSE

By

John S. Carpenter

"AFTER our last talk," said Pop to Jimmy, "I was a-thinkin' about your idee of a governor which consisted mainly of a set of speed balls, a cute little throttle an' a coupla hickeys. Now, as I told you, that rig might do kinda well for a steam engine or a turbine, but for a water turbine or a Pelton wheel, never! Listen!

"These speed governors gits their cue to git on the job from a speed change. That is, we must have a speed change before the governor knows they's anything doin', an' if we has a set of flyballs that has to do considerable work in movin' heavy gates or sich like, it's gonna take a big speed change until the speed balls gits up enough centrifugal force to do the work. Jes' right here is an important point. What we calls the 'unsensitiveness' of the governor means jes' this: If a certain set of flyballs requires a 1 per cent. change in speed before it gits pep enough to move its levers an' links an' another needs only a ½ per cent. change before it will move, then the last is jes' half as *unsensitive* as the first, an' the last will pro'bly git agoin' in half the time that the first set will, helpin' to avoid trouble in the regulation of the voltage. So the point here is, the more sensitive a governor is the more delicate is the parts connected with the flyballs. An' right here it should go without sayin' that any delicate piece of machinery is teetotally unsuitable for any sich safe-movin' job like movin' the gates of a turbine. So when a speed change occurs, we has the governor balls gently callin' a husky on the job, this gent bein' called a servomotor. An' the messenger is called pilot valve. So now fix your gentle gaze on this sketch." (See the illustration.)

"This is a diagrammatic sketch of an oil-pressure governor. A good governor wouldn't be made like that—strung out all over the place—although I do remember they was a governor on the market some time ago that uster have the oil pump up in Lizzie's room, the speed balls in the parlor, the pilot valve in the kitchen an' the servomotor down in the cellar, while all through the house they was a hundred pipes. This sketch was made simple so a feller could understand it even if he did have a few college degrees after his John Henry.

"Before anything else, I'll introduce the characters in our comedy, with a few remarks on their jobs:

"The Flyballs, alias Speed Balls, etc.—The type shown ain't a good example of flyballs, 'cause they's too much friction—internal friction—in that style. Internal friction increases the unsensitiveness. The right kind of flyball is suspended on knife-edges an' has as few joints between it an' the pilot valve as possible. Every joint has some lost motion in it an' has a bad effect on the sensitiveness. We'll take up the knife-edge flyballs in detail later. An' now:

"The Oil Brake—This gent allers reminded me o' one o' them buffer states over in Europe, keepin' the scrappers apart. In ordinary conditions in power-plant operation, the load is allers changin' a bit, an' a sensitive set of flyballs is respondin' to them changes. In the case of small changes of load this constant fussin' does more harm than good, so they puts this brake on the governor to brake small changes of load, but to act when big ones come on. They is a little adjustin' screw on the side of the critter to regulate the stability of the governor, or its sensitiveness to small load changes. The less obstructed that passage is by the screw, the smaller will be the load changes the dingus will let the governor act on; an' on the other hand, when the passage is nearly closed up, it will take a big change in load before the oil brake will let the pilot valve move. Next comes:

"The Automatic Speed-Changing Device, to automatically change the speed of the wheel or turbine from no load to full load. This is necessary so that the generators driven by the turbines will share the load between 'em in proportion to their kilowatt capacity, or else you couldn't operate such generators in parallel on account of the probability of the load shiftin' from one machine to another, an' maybe burnin' out one. Usually, the speed is 2 to 2¼ per cent. lower at full load than at no load. This permanent speed drop can be adjusted on most good governors, so that in the case of a single machine or for any other reason the speed drop can be moved if they wants. Later we take up the details of this hickey. Now we have:

"The Restoring Mechanism—This feller's job is to return, or restore, the pilot valve back to its previous position before the speed of the wheel has returned to normal. If this guy wasn't on the job, the governor would be movin' the gates too fast every time an' the speed would play hide an' seek with the load, never comin' to a stable condition. The next is:

"The Remote-Control Motor—This is usually used fer remote control of the unit, the little motor bein' on the governor an' the control switch on the switchboard. This motor is geared to the restoring mechanism, the spindle bein' threaded so it moves the pivot point up or down as the operator wants. This short, fat gent is:

"The Pilot-Valve—He is a reg'lar henpeck, havin' to do just as his wife, the oil brake, says. When the ol' gal lets him, in the case of small governors he distributes oil to the servomotor, that husky over there with the big chest. In the case of big governors, the job is too strenuous for him an' so he passes the buck to another critter called floating piston, which does the oil-distributin'. The pilot valve usually is a small piece of nickel-steel rod, hardly more than ⅝ in. in diameter, and usually is placed inside of the floating piston when they is one. The details of this will be dooly taken up later. Now comes:

"The Oil Tank—This is jes' a steel tank, sometimes made to hold pressure, an' in this case it is jes' a reservoir. Means are provided to drain an' clean out the tank. We next have:

"The Gear Pump—In a first-class governor, this is generally made with nickel-steel gears. Like other gear pumps, the suction is below an' in the center, the discharge on top and also in the center. The stubby guy:

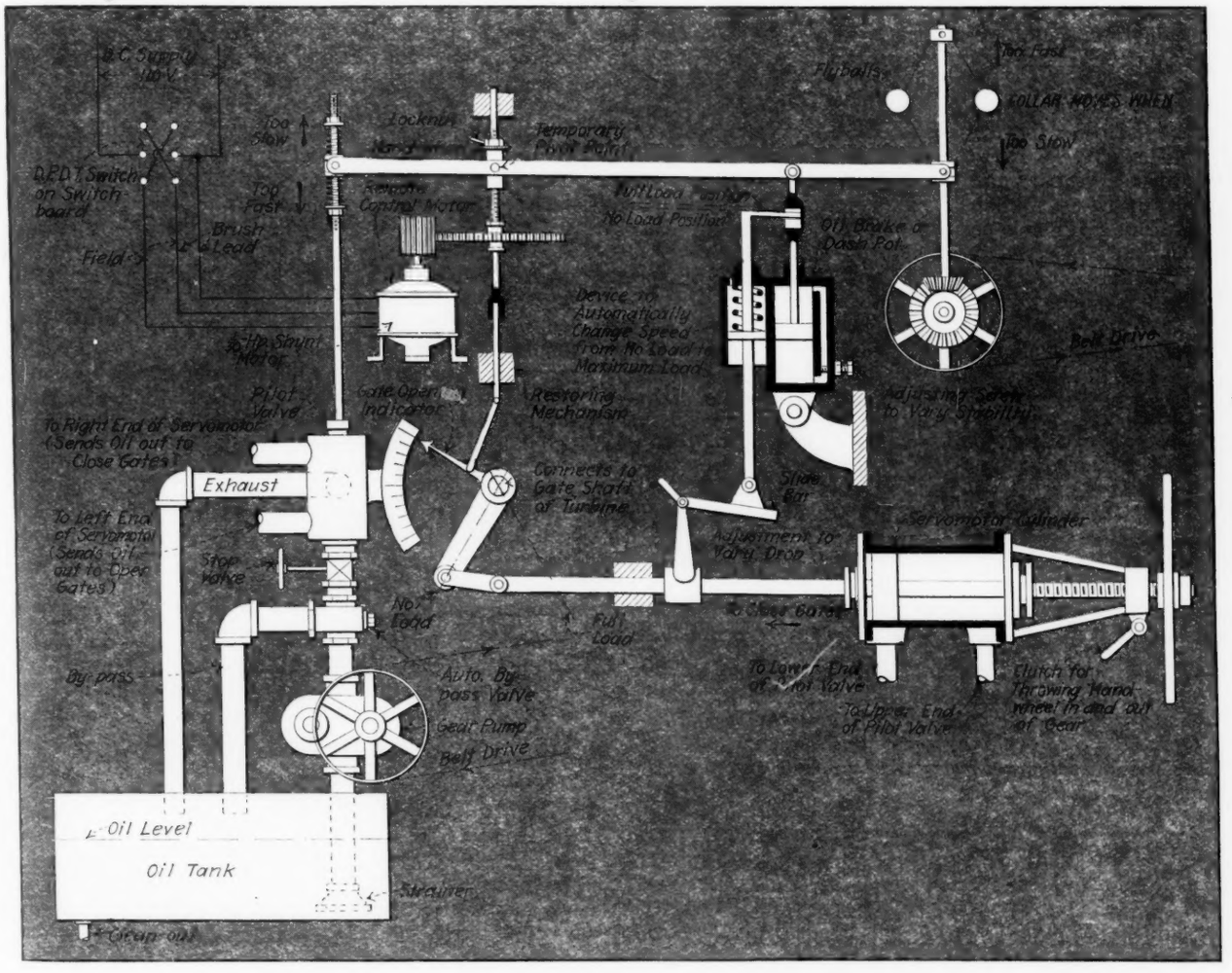
"The Bypass Valve—When the governor is not respondin' to a change in load, the oil is bypassed from the pump back to the oil tank. When the pilot valve moves the least little bit, the bypass valve closes and the gear pump pumps oil under pressure directly to the pilot valve. The oil pressures used vary from 100 to 300 lb. per sq. in. The wear on the valves an' the tendency to leakage is o' course much greater at high pressures, an' so most wise engineers tries to keep the oil pressure between 150 an' 200 lb. The smaller the governor the higher the oil pressure you gotta carry so the gates will be moved. Now the husky guy with the big chest:

"The Servomotor—In this cylinder is produced the force necessary to move the gates. The oil that comes from the pilot valve is carried to the servomotor by the piping shown, and the oil from the other side of the piston exhausts back to the oil tank through the pilot valve. And last:

"The Handwheel-Regulating Mechanism—By means of the clutch you can throw the governor out of commission an' regulate the turbine with the handwheel. This is important when you start up, 'cause you gotta git her up to speed first before you can throw the unit in on the line. The handwheel is also good if they should be any trouble with the governor. When the governor is handlin' the load, the handwheel clutch is thrown out an' the handwheel screwed back as far as possible on the piston rod, so the governor has full control."

"That's a fine description so far, Pop," declared Jimmy.

"Havin' got so far," continued Pop, "we'll now see what happens when they is, say, a 25 per cent. load change—that is, load off. The first thing that happens is that the speed balls flies out an' pulls up the lower collar. The oil brake tries to hold back for a moment because it ties the flyball collar at the pivot point an' also at the oil brake. But the force exerted by the flyballs overcomes the oil brake an' the crossbar pivots temporarily at the pivot point an' forces the pilot-valve spindle down. Jes' as soon as the pilot-valve spindle has moved enough to let a drop of oil through, the bypass valve closes an' sends pressure oil around to the right-hand end of the servomotor, or oil cylinder. This gent now gits on the job and moves the piston an' gate-shaft lever toward the closed position. In so doin' it raises the little lever on the restoring mech-



SHOWING THE ARRANGEMENT OF THE OIL-PRESSURE GOVERNOR

anism, liftin' up the pivot point an' carryin' with it the pilot-valve spindle. That natchelly shets off the oil that is agoin' 'round to the servomotor, an' as the pilot valve covers both the closin' an' the openin' ports, the piston is now locked in place, for the pipes an' servomotor is filled with oil. The oil that was on the other side of the piston was returned to the tank by way of the pilot valve an' the exhaust pipe."

"Just tell us what the automatic speed-changing device does and how it works. That thing looks mysterious."

"Well, you sees that slide bar? That does the trick all alone. The servomotor is shown in the closed position and the slide in its lowest position. I told you before, when introducin' the characters, that at full load the wheel should run a bit slower than at no load. The flyball collar must move down to increase the speed, an' this is jes' what it should be prevented from doin'. Therefore, we arranges the slide so that at full load the horizontal bar strikes the oil-brake piston rod in the hole that the bar works in an' so prevents the rod from movin' down, since the horizontal bar is supported rigidly on the slide bar. The slide bar is shown with a locknut so the speed difference at full load can be changed, if necessary, or entirely removed."

"What is that spring in the cylinder of the speed-changing device?" asked Jimmy.

"Simply to keep the slide agin the slide bar. An' the gate-openin' indicator does jes' what it says—shows how much them gates is open." Pop decided to light up as he noticed that Jimmy made remarkable progress with the cigar box.

"Now tell us how you start up a unit with such a hickey for a governor. I suppose you've got to be a college professor to run it."

"Not on your tintype!" assured Pop, blowing great clouds of smoke toward Jimmy in self-defense. "The designers of this governor knew that once in a while a flathead would git to run it, so they laid awake many nights a-thinkin' how they could make it fool-proof. They never quite did the trick, but it must be said the average run of operators has brains. This is how we does it:

"See that the stop valve below the pilot valve is closed. Throw in the handwheel clutch and move the gates to the closed position, if not there. See that the locknut on the restoring mechanism is up as high as it will screw, an' then raise the handwheel under the locknut as far as it will go. Now start the turbine slowly by means of the handwheel on the servomotor an' gradually bring it up to speed. Throw out the handwheel clutch and screw the handwheel as far toward the end of the piston rod as it will go. All this while the oil pump has been pumpin', but has been bypassin' the oil back to the oil tank through the bypass valve. Now open the stop valve, which will let oil go to the servomotor. By screwin' down the handwheel on the restoring mechanism spindle, bring the speed to normal an' then lock the handwheel with the locknut. The governor is now handlin' the load."

"And the stopping of the unit?" continued Jimmy, helping himself to another cigar.

"Why, you screws up the handwheel an' locknut on the restoring valve spindle as far as you can, throw in the clutch on the servomotor handwheel, shut the stop valve an' close the gates."

Early American Steam Boilers

By HUGH G. BOUTELL

Description of boilers that were used in pumping stations of Philadelphia at the beginning of the last century, particularly a wooden boiler installed in the old Centre Square pumping station, employing a steam pressure of 2½ lb. and supplying a beam engine whose frame was also of wood.

There is at least a certain amount of historic interest in a description of mechanical appliances designed in the early days of steam engineering and now, having fulfilled the part they were designed to play, relegated to oblivion. Usually there is little in such a description that will directly aid the engineer in his everyday work, but on the other hand the contrast which such reading is bound to bring to his mind between obsolete and present practice is sure to increase his admiration for the great advance made in the field of mechanical engineering since the introduction of steam power in the United States.

At the beginning of the last century there were very few steam engines of any kind in this country, and most of these were of the low-pressure condensing type, as introduced by Watt toward the end of the eighteenth century. A few of these engines were erected in manufacturing plants in the United States, and some were set up in the water-works for supplying the cities of New York and Philadelphia.

In the latter city two pumping stations were erected, one at the Schuylkill River and one at Centre square, both having been completed about the year 1801. The Centre Square plant contained a single-beam engine, having a steam cylinder 32 in. diameter by 6 ft. stroke and driving a double-acting pump having a cylinder 18 in. diameter with the same stroke as the engine cylinder. An excellent description of the plant was presented in a paper by Frederick Graff, C. E., before the Franklin Institute in 1876. It is somewhat surprising to learn that the main beam, supports for the main bearings, flywheel arms and other parts were made of wood, but it seems hard to believe that the boiler by which the engine was supplied with steam was also constructed of this material. Such, however, was the case, and Mr. Graff describes the construction as follows:

"The boilers were rectangular chests, made of white pine planks 5 in. thick; they were 9 ft. square inside at the ends, and 14 ft. long in the clear, braced upon the sides, top and bottom with oak scantling 10 in. square, the whole securely bolted together by 1¼ in. rods passing through the planks. Inside of this chest was placed an iron firebox 12 ft. 6 in. long, 6 ft. wide and 1 ft. 10 in. deep, with vertical flues, 6 of 15 in. diameter and 2 of 12 in. diameter; through these the water circulated, the fire acting round them and passing up into an oval flue situated just above the firebox, carried from the back of the boiler to near the front, and returned again to the back, where it entered the chimney. This firebox and flue appear to have been at first made entirely of cast iron; then a wrought-iron firebox was made, the flues still being of cast iron. This was not satisfactory on account of the unequal contrac-

tion and expansion of the two metals causing leakage, and eventually wrought-iron flues were also put in.

"Great advantage was at the time supposed to be gained by the non-conducting powers of the wood, and also by the vertical flues in the firebox."

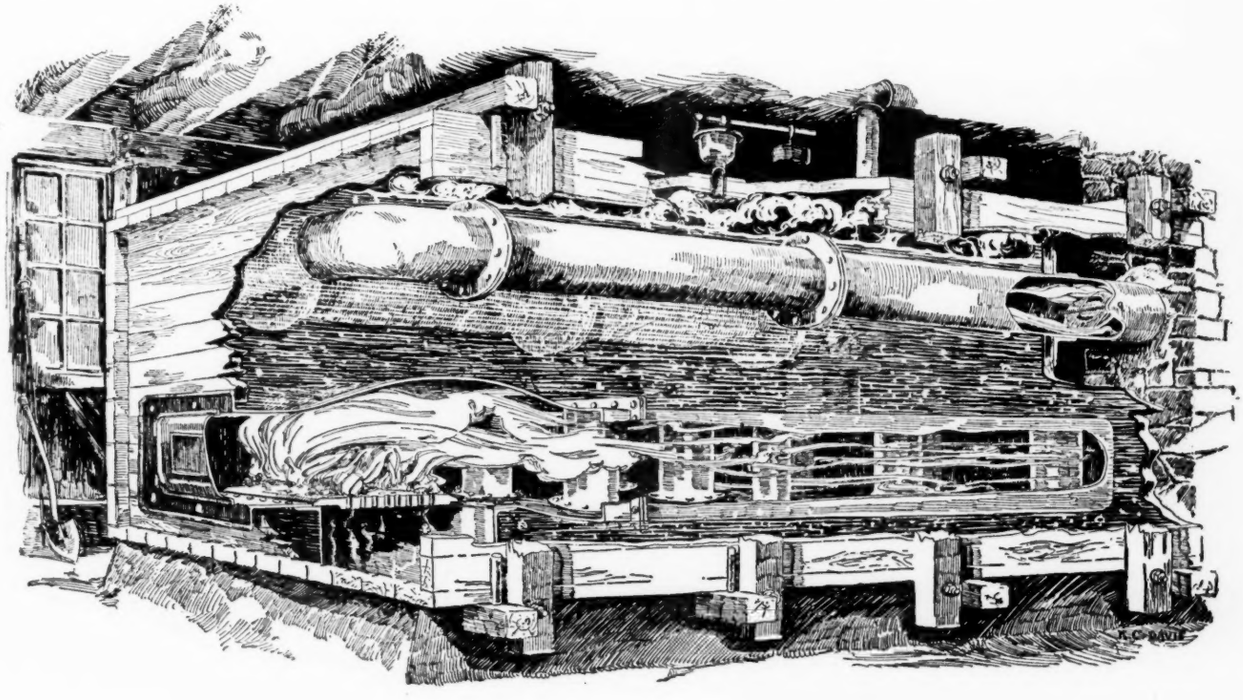
At the time this boiler was constructed, wood had been used with considerable success for making vats used in distilling, and it was supposed that wooden boilers, having to contain only comparatively pure water and steam, would be even more satisfactory. The steam pressure carried by the boiler in the pumping station at Centre Square is recorded as having been 2½ lb. per sq. in., but even at this low pressure the boilers gave trouble. Apparently they remained in good shape below the water line, but the steam rotted the wood very quickly, for a description written by Mr. Benjamin H. Latrobe, at the time the boiler was in use, contains this odd comment: "That there is a great saving" (in the use of wood over iron boilers) "is certain; and while the wooden boilers continue steam-tight (for that part which contains the water gives no trouble), they are certainly equal, if not superior, to every other. The wood, however, which is above the water, and is acted upon by the steam, seems to lose its solidity in the course of time, and steam leaks arise in the joints, and wherever a bolt passes through. The joint leaks may for a considerable time be easily stopped by screwing up the bolts that hold the planks together; but it is not so easy to cure the bolt leaks, for the bolt, when screwed up, bends the top or the sides inwards, and forces new leaks, either along the corners, or at some other bolt hole. I do not, however, believe that everything has as yet been done, which could be done, to obviate these defects. A conical wooden boiler hooped would not be subject to some of them: such a one has been applied by Mr. Oliver Evans to his small steam engine. During two years which have elapsed since the boilers of the public engines have been erected, much has been done to improve them; whether the last boiler will prove as perfect in its woodwork, as it is in its furnaces and flues, is still to be ascertained by experience. At present nothing can work better.

"I will only mention one other circumstance, the knowledge of which may prevent similar mischief. In the first boiler erected in Philadelphia, oak timber was used to support the sides, bottom and top of the boilers, the plank of which was white pine, 4 in. thick. In less than a year it was discovered that the substance of the pine plank to the depth of an inch was entirely destroyed by the acid of the oak. Means were then used to prevent its further action, by the intervention of putty and pasteboard; and in most cases by substituting pine timbers in the place of oak."

As the wooden boilers did not prove satisfactory, after a few years of service, they were replaced by others made of cast-iron plates which remained in service until both the Schuylkill and Centre Square pumping stations were discontinued due to opening the plant at Fairmont in 1815.

This station contained a beam engine similar to the ones used at the earlier plants and supplied with steam at 2½ lb. pressure by a cast-iron boiler. In the same station Oliver Evans erected a high-pressure pumping engine about 1817, and provided it with four cylindrical boilers made of wrought iron, 27 in. in diameter and 27 ft. long. Mr. Graff records that steam was often raised in these boilers to a pressure of 220 lb. per sq. in., which would, of course, be considered fairly high pressure in stationary work today. I have been unable to ascertain the exact construction of these boilers, but judging from the dimensions it would appear likely that they were simply plain cylinders without flues of any kind.

It was apparently the idea of those in charge of the water-works to determine the relative merits of high and low pressure steam for pumping engines, but it is doubtful if much of a comparison was made; as the high-pressure boilers exploded on June 20, 1818, and killed three men. The Fairmont steam pumping plant was shut down in 1822, when a new station using water power to drive the pumps was completed. The buildings of this plant still stand on the bank of the Schuylkill River, though all trace of the machinery which they once contained has been removed.



A Perspective of the Fuel-Oil Situation

By CHARLES H. BROMLEY
Associate Editor of Power

Here is an Article Your Manager or Directors Will Want To Read. Hand It to Them

What is there to all this talk about fuel oil?
Why is it creating such widespread interest?
Where is it applicable, and under what conditions?
What are its sources and what about the continuity of supply?
Wherein does it surpass coal in the matter of cost and boiler performance?
How does it influence the labor situation in one's power plant?
What problems are connected with its storage and handling?

These are some of the more pressing questions engineers are asking. The article herewith aims merely to tell a few things that may help those who are asking such questions.

In the first place practically all fuel oil used in furnaces in the United States, excepting in some sections on the Gulf and in California, comes from Mexico, chiefly out of Tampico. As delivered to the consumers, it is topped; that is, the naphthas, gasolines and kerosenes have been driven off. This does not materially decrease its value for boiler furnace fuel as compared with crude petroleum. In fact, topping improves it as a boiler fuel, because the highly volatile constituents are no longer present to give trouble or create undue risk in storage and handling.

The widespread interest in oil as fuel arises because of several reasons. The all-impelling one is, of course, cost as compared with coal. Then, too, coal is difficult to obtain. The other day a large plant on the Boston waterfront received a shipment of New River coal. It was the first in many months—in Boston, the chief port to which New River coal used to go. The purchaser never had anything else in his bunker until recently. In fact, compelled to accept coals high in sulphur, he has had fires in the wooden bunker, something unknown here with the coal formerly available. This plant will be ready to burn oil as soon as the concrete oil-storage tank is sufficiently dry.

Europe is shivering, its industries are handicapped, its hotels made inconvenient and uncomfortable—all because of lack of coal. Of money Europe has much, and it is willing to pay, and is paying, considerable for good American coal. At this writing the freight rate from New York on coal is $26 on 1000 tons displacement to Marseilles, $31 on 800 tons to Venice and $25 on 1000 tons to Hamburg. So it is well worth while, if one has steamers, to use them in this Atlantic trade. And further, because of the freight rate, one aims to transport only the highest-grade coal. The more heat units per ton of cargo space the relatively lower the freight rate, for high-grade coals always bring comparatively high prices.

In fact, New England engineers, the oldest and largest users of America's high-grade coal, are asking if perchance this coal has not about petered out. Many seem to believe that for them it has. But a survey will show that there is much of it in West Virginia, and that, while disturbing, the situation is not as serious as some seem to believe.

And the situation does not look as though it was soon going to improve materially. Perhaps this is reflected in the action of one large company on the Atlantic Coast. The present New England Fuel and Transportation Co. is one of the largest, if not the largest, coal company in New England. It has gone into the oil business through the newly organized Beacon Oil Co., with offices in Boston. This company is now building a refinery on tidewater at Everett, Mass., with a capacity of 6000 bbl. per day and storage for 6,000,000 bbl. This plant will soon be finished. The crude will come from Mexico. Two railroad connections are provided, the Boston & Maine and the Boston & Albany.

Farther down the coast at East Branford, Mass., near Fore River, the Massachusetts Oil Refining Co. is building a large refinery. The capacity figures I do not have, but understand they are large.

But of all recent moves in the oil business none has created such a stir as that of the Standard Oil Co. of New York. This company has just purchased a mile of harbor front at East Providence, R. I., the property extending back for three miles. Here a great tank farm will be erected, making Providence perhaps the largest in the world. The investment so far represents $18,000,000.

The Mexican Petroleum Corporation, which may be said to be the big pioneer in fuel oil along the Atlantic Coast, has established large storage stations at Providence, Boston and Portland. Before these were built, stations had already been conveniently located farther south and on the Gulf. This company's activities had done much to further oil before the war; but when the conflict broke in on us, the Government took over most of the company's tankers. All but two of these have been returned, and now the company has 19 tankers taking oil out of Tampico. The war stopped fuel-oil development too because so much was required for the Allied Navies. Enough could not be rushed to Europe. In fact, the shortage was so great that, when American naval officers got abroad to prepare for our war activities, they found it necessary to send coal-burning battleships. So the intense application now going on was to be expected—was expected, as may be seen by reference to articles in *Power* at the time.

Where is it applicable and under what conditions?

Oil is the cleanest, most convenient fuel used. It is applicable wherever coal may be burned in furnaces. It may be used in small as well as large power plants.

Wherein does it surpass coal in the matter of cost and boiler performance?

Price of oil alone is not paramount, particularly in a plant changing from coal to oil. The cost of equipping for oil, including adequate storage, is a vital factor, though obviously there are others. But as a fuel, as a steam producer, roughly 4½ bbl. (42-gal. barrels) are equivalent to a long ton of good coal, or a pound of oil equals a pound and a half of good coal.

But oil is better than that. That value is based on the relative heat units in coal and oil. Complete combustion means the complete consumption of the combustible in a fuel brought about by the supply of oxygen of the air. Perfect combustion is the use of only as much oxygen as is theoretically required to complete-

ly burn the fuel. Fuels must be gasified before they burn, and obviously oil, which has no ash, which does not form a fuel bed with clinkers, may more easily be broken up, atomized and gasified than coal. And so with oil each carbon atom the more readily finds the two oxygen atoms needed for its complete combustion, for combustion is good or poor according as the mixture of air for combustion and gases for combustion is intimate and rapid and the air in not too great excess.

Because of this mechanical advantage which oil possesses over coal it gives, in the average plant, a greater combined boiler and furnace efficiency by from 6 to 8 per cent., all other conditions being equal. That is, with a given plant, load and labor, the over-all efficiency will be higher for oil by the amounts given. But be it understood that experience shows that materially no greater combined efficiency is possible with oil than with coal. A first-class fireman, with first-class stoker and coal adopted and of good quality, can show practically as good results as one can with oil—but it cannot be maintained for so long.

How does fuel oil influence the labor situation in one's plant?

It may not affect it at all or it may astonishingly minimize it, depending upon the number of active boilers in service in the plant, whether the boilers are hand- or stoker-fired, and the quality of coal used. It is increasingly difficult to get good firemen, particularly in hand-fired plants. Boiler-room labor troubles are usually like the poor—always with us. One competent man can handle four times as many boilers using oil as he can using coal. Of course the ratio is but the roughest kind of comparison, for it is plain that a plant having three boilers and using one or two men could not reduce its labor charge by changing from coal to oil. On the other hand, the American Woolen Mills in Lawrence, Mass., large steam users, reduced their boiler-room force more than two-score men for the same steaming capacity when they changed from coal to oil. There are some small plants where the engineer may do his own firing with oil where he could not with coal; but no reduction in labor charge should be expected where but a few men are employed in the boiler room. Oil is a fuel that men like to use; it is clean, there is no dust, no inconvenient handling, no ashes to remove and no heavy lifting or hauling connected with it. It contents the man who uses it, and here lies its power as a reducer of boiler-room labor troubles.

What problems are connected with its storage and handling?

It depends upon the location of the consumer, whether there will be problems worthy of the name. The contracts of the companies supplying the oil usually require that the purchaser's storage facilities be sufficient to hold three weeks' supply. This is not always necessary. We are surely going to see the oil companies establish and maintain tank-truck service in far larger volume than at present. This will simplify the storage question for the consumer. The number of tank cars (railway) is increasing rapidly, and steps are being taken to facilitate their movement to consumers not on tank-truck routes or on tidewater. In the writer's opinion storage and delivery are things to worry about only in exceptional cases.

For the small plant the steel storage tank is popular, while the large and medium-sized plant often finds concrete desirable. Experience is showing, however, that the actual cost of constructing storage tanks is in almost every case higher than the estimated cost.

The insurance regulations for fuel oil are, on the whole, easy to meet. At least one large company is now revising its regulations, and these will help rather than make it more difficult for the consumer. Storage tanks are required to be underground, the lowest point in the oil-burning system, and properly vented.

What about the continuity of supply?

Here is the question that so many run smoothly to and then come to a full stop with more or less shock. Nobody knows much about it. But when an oil company is willing to make a three or more years contract and shows that during the war it never failed to make delivery to a customer, that there is every reason to believe there is more oil available in the ground than even they hoped, that many years of much-disturbed political conditions in Mexico have failed to shut off the supply—when these facts are known, one is well on the way toward being convinced of the value of oil as a boiler fuel, though the careful man will want to go further with his studies. This is particularly true of the man responsible for large industrial power plants and public-utility stations.

Obviously, oil must not only be available in sufficient quantity and delivery made with satisfactory regularity, but for the large consumer the supply must be assured at least for a period long enough to raise no question about making the investment pay. There enters into this the question of price of oil and price of coal. It is plain that the oil must be low enough in price to pay for the change-over investment in a reasonable time. In the large plant the reduction in labor charge effected by oil will help materially when credited to the investment, as it should be.

Naturally, local conditions will greatly influence the magnitude of the investment in storage facilities, the greatest item of expense in the change from coal to oil. For example, the Narrangansett Electric Lighting Co. is now installing oil-burning equipment. The plant has modern underfeed stokers and is but a few years old. It is on tidewater, and coal delivery is by barge. Huge storage depots of several petroleum companies are virtually next door. The Standard Oil Co. has just purchased a mile of water front across the river and here will erect one of the largest tank farms in the world. This company has the Narragansett Electric Co's contract. It is quite certain that no large storage capacity need be provided by the purchaser in this case. There are some other large stations on the Atlantic waterfront almost as favorably situated. Certainly, these should be able to make the change at a cost very much lower than the station less favorably situated. Fuel oil is a zone proposition.

The 1919 production of Mexican petroleum will perhaps exceed 80,000,000 bbl.; the exports for the first six months of this year were 35,000,000 bbl. Surveys have placed the potential production of Mexico at 1,000,000 bbl. per day. Today Mexican wells each give from 10,000 to 60,000 bbl. per day. Reports have it that the oil interests are now ready to spend $100,000,000 on further oil developments in Mexico. From the figures in this article and others available, it is evident the oil companies are backing up their faith with money.

The navies of the world, also the merchant marine, more and more rely upon oil as a fuel. At least half the vessels of the Emergency Fleet Corporation use it. Oil is fast becoming the dominant fuel of the sea. Sea traffic is sea power, and sea power is world power; not necessarily for armed conquest, but certainly for

commercial conquest. Oil, then, is extremely vital to a nation's well-being. It bears a close relation to its stomach and its pocketbook, and therefore to its commercial, diplomatic and war departments.

Great Britain, which has seldom been accused of shortsightedness in its world-wide commercial affairs, has long been busy acquiring control of the world's petroleum resources. One is no longer surprised to learn that control of petroleum fields was one of the chief factors in General Allenby's Palestine Campaign. There is huge foreign capital invested in Mexican oil by the two most powerful countries on earth. They are bound to protect those of their citizens who have vested interests there. Even more, our Monroe Doctrine makes it obligatory upon the United States to do so for ourselves and all foreign investors.

Now then, is it to be imagined that these powers will accept any really unjust and harmful political action by Mexico? Of course not.

But Mexico has just as much right to nationalize her oil fields as England has to nationalize her coal fields. If she does, she must do so with extreme caution, and equity and justice to foreign investors, lest some day soon the forces which seemingly have exerted every effort to bring about a state of war that Mexican oil fields may be made another Saar Valley, will have had their way.

Politically, it is as plain as a pikestaff that Mexico must be eminently fair with her foreign investors or suffer, to her, a crushing economic loss. Needless to say, she is entitled to the same treatment from her powerful neighbor.

Atomic Energy as a Source of Power

A special cable to the New York *Times* says: Sir Oliver Lodge, speaking before the Royal Society of Arts, amplified a lecture on atomic energy which he delivered in Birmingham in September. Predicting that a time would come when atomic energy would supersede coal as the source of power, Sir Oliver said:

A radium atom firing off a particle which turns out to be a positive charged atom of helium is like a two-ton gun firing a 100-pound shot. Before it has exhausted its ammunition, it fires off five such projectiles and then settles down into a quieter existence as lead or something chemically indistinguishable from that substance.

It would seem that all substances of very high atomic weight are liable to behave in this way. It is only a question of degree, and it is not by any means their whole energy that they thus exhibit; it is the energy they expend and get rid of—their waste energy—that we perceive. When their active transformations have ceased and left them in a stable state, like lead, gold, silver, copper, iron, or any common element, we are not to suppose that because they are quiescent, therefore they have no store of internal energy. Anyone looking at cordite might think it harmless; and it is till suitable stimulus is applied.

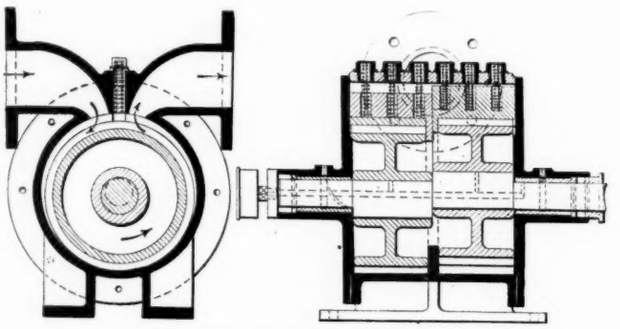
I think we are on the brink of a discovery. It may be a century, but I do not suppose our descendants will be using chemical energy. Instead of burning 1000 tons of coal, they will take energy out of an ounce or two of matter.

Squeegee Rotary Pump

A type of pump, the principle of which is not new, but which, as designed, has carried out a new idea, is known as the "Squeegee" rotary pump, and according to *Engineering* is manufactured by the Avamore Engineering Co., Ltd., of Queen Victoria St., London. The pump is of the positive type and is made at present in six standard sizes. Its leading features are simplicity of design and high speed, and owing to the fact that the rotor has a rolling motion imparted by the casing, the wear is reduced to a minimum. It is suitable for pumping gritty or muddy water and, by using an all-metal roller, oil.

The pump consists of six main parts—the casing, two cover cases, shaft and two rotors, which in the standard design are covered with India rubber. The casing and rotor disks are generally made of cast iron, but bronze and other special metals can be used. The shaft is of steel and is carried in two bearings. The eccentrics, which are solid with the shaft and have only a small throw, impart movement to the rotors, which are a loose fit on the eccentrics.

The displacement is caused by the rolling of the rotors when driven around by the eccentrics on the main



SECTION THROUGH THE PUMP

shaft; but as this shaft is rotated in an anti-clockwise direction, as shown by the arrow in the illustration, the rotor rolls around in the same direction, but, being smaller in circumference than the track in the casing, it rotates in a clockwise direction, but only in proportion to the difference between the circumference of the casing or track and that of the rotor. The point of contact between the rotor and the casing is constantly rolling forward in an anti-clockwise direction. The shaft may be driven from either end and in either direction, and for this reason the inlet and outlet connection are interchangeable and therefore are not specially marked.

Small deflecting valves, one for each rotor, are placed in the upper portion of the casing, and are kept in position against the rotor by the small springs shown. The pumps are made in sizes from 1 to 4 in. in diameter pipe connection, with a capacity of from 700 to 13,000 gal. per hour when run at 1250 r.p.m. and 720 r.p.m., respectively. The pump may be run at any speed up to the maximum and will deliver a proportional quantity of the liquid being pumped against any head within the limit of 100 ft. for the smaller sizes and 150 ft. for the larger.

Twenty-five years ago the highest voltage used was 11,000; two years later, or in 1896, this was increased to 22,000. Transmission-line voltages have kept increasing in value until in 1912 the 150,000-volt line was put in operation in California on the Big Creek development of the Pacific Gas and Electric Co. The present indications are that the use of 220,000 volts for long-distance transmission of electric energy may be looked for in the very near future.

The first 1000-volt transformer had a capacity of 9 kw. and was built 30 years ago. The design of 35,000-kv.-a. transformers for 220,000 volts is being looked upon as a possibility of the near future.

A Self-Adjusting Spring Thrust Bearing

A careful study of the difficulties experienced with the types of thrust bearings used in supporting the heavy loads of waterwheels and electric generators driven by them, has led to the design by the General Electric Co. of the flexible spring thrust bearing described here. It is now used in G-E vertical alternators.

DEVELOPMENT of machines in sizes not long ago unthought of, with rotating elements of great weight, has brought about complications in the details of bearing design. The manufacture of huge, hydraulically actuated direct-drive generators has forced attention to the method of supporting their great revolving parts. A single thrust bearing on these vertical waterwheel-driven generators has to support the rotor, the waterwheel and the thrust of the water. One of the serious difficulties encountered in the development of larger sizes was a satisfactory means for supporting these great weights. These loads have caused considerable trouble with the bearings in use, such as the wiping of the babbitted surfaces upon starting and stopping, sometimes requiring the rescraping of the surfaces or sometimes the installation of new parts.

This spring-supported thrust bearing automatically adjusts itself to unequal loading due to inaccuracies in workmanship or alignment. The design is based on a theory which is fundamentally correct, and which enables the production of a bearing much more simple to make than the standard forms of thrust bearing previously used. While some other types of bearings may be carefully adjusted when installed, a distinctive feature of the spring-supported bearing is that it will automatically adjust itself while in operation, if there is a loss of alignment due to the settling of the foundation or to other causes.

On large machines the machining of the part is not as accurate as on small units. With an oil film between the thrust-bearing surfaces of about three ten-thousandths of an inch, it is evident that even with good machining and erection, very severe conditions may exist for any thrust bearing without a yielding support.

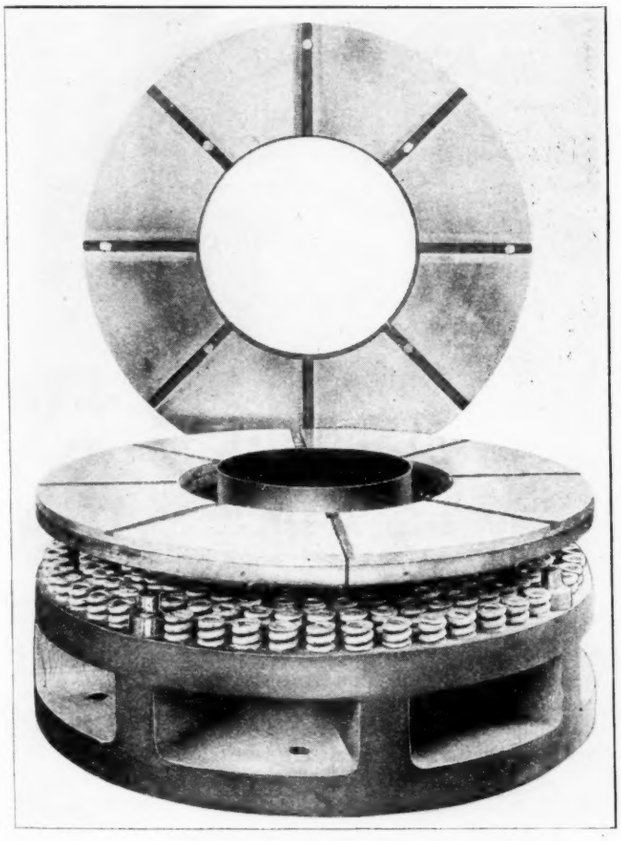


FIG. 1. ASSEMBLY OF THE THRUST BEARING

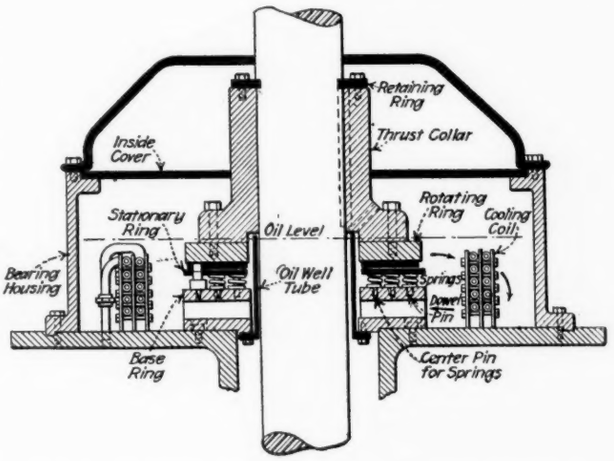


FIG. 2. SECTION OF THE SPRING THRUST BEARING

To maintain a film of oil of fairly uniform thickness in other types of bearings now in use, it is necessary that the parts which form the bearing surface should be exceedingly rigid so that the deflection of the bearing surface shall be small. It is for this reason that the shells of ordinary journal bearings are made stiff so that they will do some supporting even at the ends. The ideal condition would be to have the deflection of the bearings and shaft the same, but in practice this cannot be accomplished. The spring thrust bearing approximates this condition, and it is based on the idea for a bearing surface which is so yielding, flexible and elastic that it may follow the irregularities of the rotating surface without creating at any point a unit pressure sufficient to destroy the oil film.

The heat generated between the rubbing surfaces of the bearing is dissipated in two ways: First, by transmission through the runner and babbitted ring to the oil; or, second, by the oil passing between the surfaces. Assuming that the oil film is three ten-thousandths of an inch in thickness, and that the velocity of the oil is one-half that of the rotating surface in a thrust bearing 44 in. outside diameter, running at 200 r.p.m., without any grooves in the runner, the rate of flow in the film is about one-third of a gallon per minute.

This is but a small proportion of the cooling oil required, which indicates that the greater part of the heat passes through the metal plates. The thin babbitted ring used in this bearing will transmit this heat at a much higher rate than will a thick plate, and thus the temperature at the rubbing surfaces is reduced. On the other hand, with eight grooves in the runner, any part of the babbitted surfaces is swept over by a stream of

cold oil at a high radial velocity, 25 times per second.

A spring thrust bearing of typical design is shown in Figs. 1 and 2. The bearing consists of a runner of a special grade of cast iron resting on a thin steel disk with a babbitted surface. This babbitted ring, in turn,

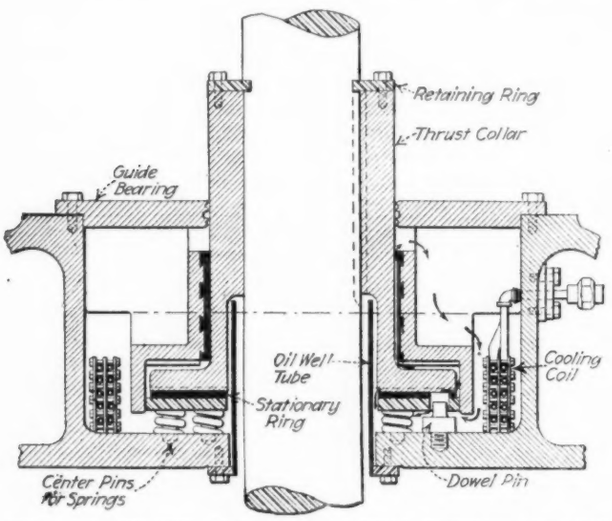


FIG. 3. COMBINED GUIDE AND SPRING THRUST BEARING

rests on short helical springs and is held against rotation by dowel pins. The high base casting shown is used in connection with a deep housing in case it is desired to increase the amount of oil in the surrounding bath.

The tube in the center forms a retaining wall around the shaft for the oil. The springs shown are wound of ½-in. round wire and have an outside diameter of 2 in. and a free length of 1½ in. Under load the springs close about 3/32 in., and the total pressure is distributed upon all of them.

The cast-iron runner is located on the underside of the thrust collar, which is fastened to the top end of the shaft by means of a retaining ring. The bearing surface of this runner is finished with extreme accuracy and is given a high polish. The babbitted surface upon which this runner revolves has radial oil grooves cut in it, and it is cut entirely through in one of these grooves to prevent any tendency to dish or warp under changes in temperature. This surface is given a tool finish in the shop. It is not necessary to give this babbitt surface any further finish such as hand scraping to the iron runner or to a surface plate, which is generally done in the case of the other types of bearings.

The springs are designed to be stressed to only a very small proportion of their capacity, which insures against the possibility of their taking a permanent set. The oil-retaining tube in the center is welded to a supporting ring, which is bolted to the base ring.

By means of the yielding support furnished by the springs, it is possible to avoid excessive pressure at any point on the surface of the bearing. Thus it has been found safe to run at a much higher unit pressure than when there is no method of relieving an undue stress which may occur over a small part of the bearing.

In the absence of dirt and grit, bearing failures are usually due to the squeezing out of the oil film. The pressure necessary to accomplish this is much greater than is generally supposed. In one case a pressure of 5000 lb. per sq. in. was carried for several hours without any damage to the babbitt surface.

A type of thrust bearing which permits the use of high pressures has a much better efficiency than one in which a lower unit pressure is used. In a bearing having a continuous oil film, the only friction loss is that due to the viscosity of the oil, or its resistance to the continual shearing of the film. Therefore the friction in the bearing lessens with the decrease in the area of the film.

With the use of high unit pressures upon thrust bearings the mean diameter may be reduced and consequently the rubbing speed is also reduced. The coefficient of friction is also lowered owing to reduced speed and an oil film of less area.

The following table shows a comparison between a large and a small bearing with the same total load. The advantage in selecting a type of bearing which permits the use of high unit pressures is apparent.

	Small	Large
Bearing number	1	2
Revolutions per minute	200	200
Total load, lb.	300,000	300,000
Outside diameter of bearing, in.	35	46
Inside diameter of bearing, in.	17.5	17.5
Net area, sq. in.	600	1200
Pressure, lb. per sq. in.	500	250
Average rubbing speed, ft. per min.	1370	1670
Coefficient of friction	0.0018	0.0033
Kilowatt loss	16.7	38
Horsepower loss	22.5	51

The friction loss in the small bearing is less than

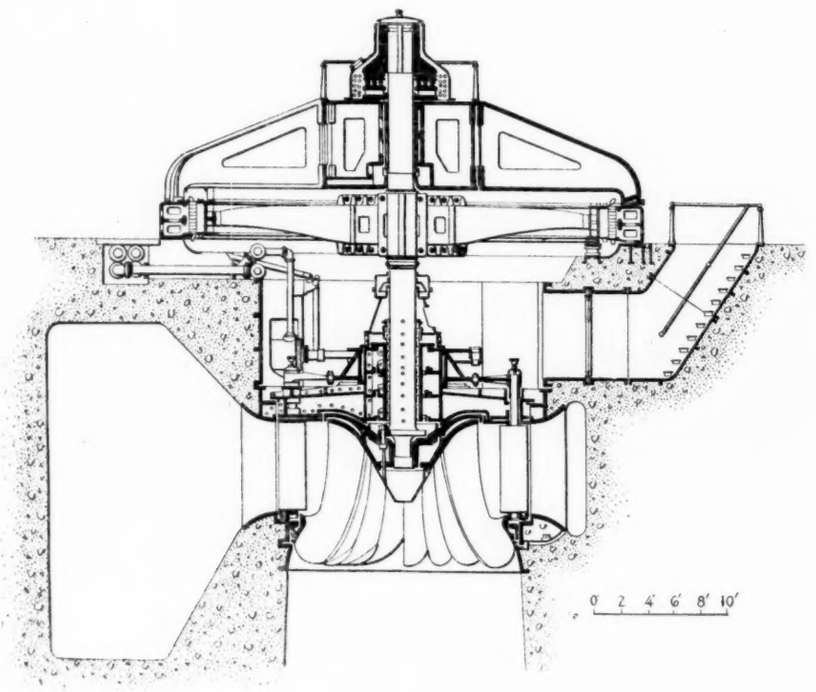


FIG. 4. SECTION OF TURBINE AND GENERATOR SHOWING LOCATION OF THRUST BEARING

half of what it is in the large bearing.

The customary central-station oiling system used in hydro-electric power plants having large vertical generators provides for a constant supply of cool oil to the guide bearings and to the thrust bearings. The amount

of oil to the guide bearing is small compared with that to the thrust bearing. The quantity of oil circulating from a station oiling system to the thrust-bearing housing of a large generator, according to the usual method, requires an extensive equipment of large pipes, pumps, filters and tanks with coils for cooling the oil at some point in the system. Since the practice of passing the oil through the bearing housing to remove the heat generated between the rotating surfaces involves the handling of so much oil, a more simple system has been adopted.

For the proper lubrication of a thrust bearing the only requirement is a bath of clean oil, from which the heat is being removed as fast as it is generated in the bearing. The General Electric Co. has introduced the spring supported thrust-bearing features, and at the same time provides a guide bearing, both bearings being contained in the same housing and lubricated and cooled by the same oil. The cross-section, Fig. 3, shows the constructional details of this combined guide and spring thrust bearing. The rotating grooves of the bearing pump the oil through the guide bearing, thereby insuring it an ample supply. The oil flowing down from the top of the guide bearing comes in contact with the copper coils, which abstract the heat from it. It is then drawn in through the radial grooves of the thrust bearing. The combination of the guide and thrust bearings in this manner effects a considerable economy of space.

At Gatun Locks hydro-electric station, Panama Canal, there are three units in which spring thrust bearings

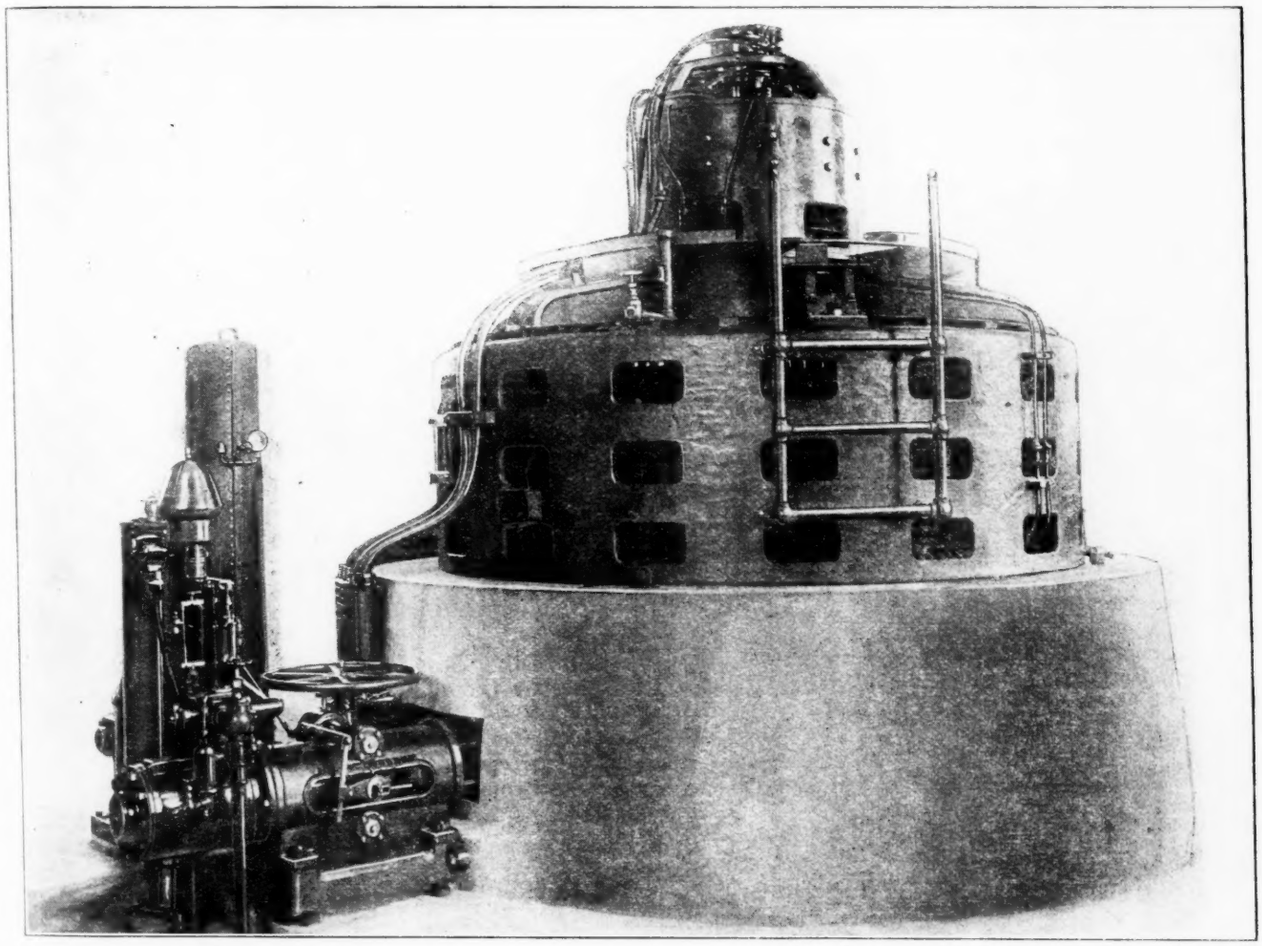


FIG. 5. HYDRAULIC TURBINE EQUIPPED WITH SPRING THRUST BEARING

use of cooling coils, immersed in the oil in the bearing housing, through which water is circulated. These cooling coils abstract the heat from the oil surrounding the bearing, and a considerable saving in expensive equipment has been effected by the adoption of this method.

The oil is circulated about the cooling coils by the pumping action of the radial grooves in the rotating surface of the thrust bearing.

This method of cooling the oil was adopted at the Cedar Rapids Station for the last two units installed there. Note the position of the water-cooling coils in the spring thrust bearing housing.

For use in the smaller-sized vertical generating units a combined guide and spring thrust bearing has been designed. This retains all the advantages of other have replaced another type which was formerly used there. A new and larger unit, which has been added to the original equipment, is also provided with a spring thrust-bearing.

Figs. 4 and 5 show generating units equipped with the combined guide and spring thrust bearing. A good idea of the economy of space effected by this combination may be obtained from the photograph.

In addition to their use on generators, these bearings are in use on ships to take the thrust of the propeller shaft; and in these installations the results have been uniformly satisfactory. The principle on which the design of the spring thrust bearing is based is one which can be practically applied to the solution of many bearing problems.

Coal Prices and Coal Profits

THE diagram, Fig. 1, is reproduced from the United States Geological Survey Bulletin, "Prices of Coal and Coke 1913-1918," by C. E. Lesher. The explanation accompanying it is as follows:

1, 2. The downward trend of the price of bituminous coal in 1913, 1914 and 1915 is shown by both the spot prices and the average prices realized. From a general average spot price of $1.47 in January, 1913 (1), prices declined to $1.14 in July, 1915 (2).

3. The strength of the demand in the winter of 1915-1916, particularly manifested in the Eastern States, is indicated in the rise in the general average spot price to $1.54 (3).

4. The highest point reached by the general average spot price was $3.77 in June, 1917 (4).

5. The amount of reduction effected by the Peabody prices is well illustrated by the drop in the curves from (4) to (5).

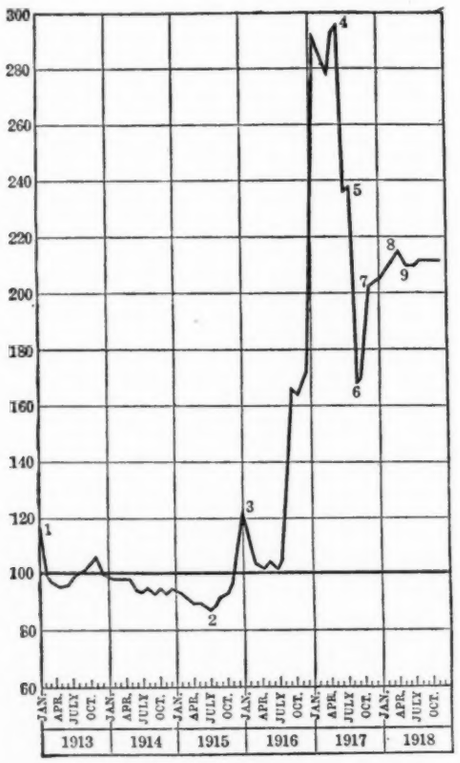


FIG. 1. RELATIVE SPOT PRICES OF ALL BITUMINOUS COAL PRODUCED IN THE UNITED STATES, 1913-18

6. Likewise, the further decrease in the general level of prices brought about by the President's price of Aug. 21, 1917, is shown by the drop in the curves from (5) to (6).

7. The general effect of prices of bituminous coal of the wage advance in November, 1917, is indicated by the rise from (6) to (7).

8. Advances in price in various fields authorized by the Fuel Administrator, as the result of the investigations of the cost of mining, raised the general level gradually to a maximum under Government control in May, 1918 (8).

9. The general reduction in price of 10 cents a ton on all bituminous coal ordered May 25, 1918, is reflected in the curves at (9).

The tables and their respective diagrams are reproduced from the Coal Report of the Federal Trades Commission for Pennsylvania Bituminous. Table I shows the distribution from time to time between the items of labor supplies and general expense and margin to operator of each dollar paid by the purchaser for coal to the operator for the central field in Pennsylvania. Chart 13 shows these facts in graphic form. Table II shows the same facts for varying periods and by the calendar years 1916-17-18, and is the basis of Chart 14.

It will be noticed that the part of the amount paid by the purchaser, which went to labor, varied greatly. It was highest (66 per cent.) in 1919 and lowest (43 per cent.) during the period April-August, 1917, following the expiration of the 1916 contracts and just preceding the establishment of governmental regulation.

TABLE I. DISTRIBUTION OF THE AMOUNT PAID BY THE PURCHASER BETWEEN THE VARIOUS PRINCIPAL COSTS AND THE MARGINS, BASED ON EACH DOLLAR OF SALES REALIZATION, 1917-18, BY MONTHS.

Month	Labor, Cents	Supplies, Cents	General expense, Cents	Total f. o. b. mine, Cents	Margin Cents
1917					
January	51	8	16	75	25
February	49	7	16	72	28
March	48	7	15	70	30
April	44	7	14	65	35
May	43	9	12	64	36
June	42	8	11	61	39
July	43	9	11	63	37
August	44	10	12	66	34
September	45	9	13	67	33
October	46	9	13	68	32
November	52	9	11	72	28
December	54	9	14	77	23
1918					
January	55	8	11	74	26
February	52	8	11	71	29
March	49	8	10	67	33
April	51	9	11	71	29
May	52	10	11	73	27
June	53	8	11	72	28
July	54	9	11	74	26
August	54	9	10	73	27
September	57	10	11	78	22
October	58	11	11	80	20
November	60	13	13	86	14
December	62	13	14	89	11

for the last nine months of 1918 (April-December), when practically the entire output of the mine was subject to the price regulation of the Fuel Administration, the share of labor was 56 per cent. of the amount paid by the purchaser for coal.

It will also be noticed that the part of the amount paid which went to the operator—that is, the margin—varies greatly. It was lowest (6 per cent.) in 1916 and highest (36 per cent.) during the period April-August, 1917. It must not, however, be supposed that such margins were all clear profit to the operators. The Commission's "revised" cost figures exclude any charge for interest, income and excess-profits taxes, donations, etc., which are expenses which, while not

TABLE II. DISTRIBUTION OF THE AMOUNT PAID BY THE PURCHASER BETWEEN THE VARIOUS PRINCIPAL COSTS AND THE MARGIN, BASED ON EACH DOLLAR OF SALES REALIZATION, 1916-1918, BY VARYING PERIODS AND BY CALENDAR YEARS.

Period	Labor, Cents	Supplies, Cents	General expense, Cents	Total f. o. b. mine, Cents	Margin Cents
Year 1916	66	7	21	94	6
January-March, 1917	50	7	15	72	28
April-August, 1917	43	9	12	64	36
September-October, 1917	46	9	13	68	32
November, 1917-March, 1918	52	8	12	72	28
April-December, 1918	56	10	11	77	23
Year 1916	66	7	21	94	6
Year 1917	46	9	13	68	32
Year 1918	55	9	11	75	25

entering into operating cost, must be met from the margin; nor is there any allowance in the total f.o.b. mine cost for the expense of selling the coal.

Considering the total investment as the amount necessary to operate its business, whether in the form of capital stock and surplus, bonds or other borrowed money, the return on the total investment in the business, after deducting the estimated selling expense from the margin and before deducting interest on borrowed money or Federal income and excess-profits taxes, is

shown in the following statement for the years 1916, 1917 and 1918:

	1916	1917	1918
Margin between f. o. b. mine cost and sales realization	$0.080	$0.920	$0.780
Estimated selling expense	0.015	0.015	0.015
Return on total investment, before deducting interest on borrowed money and Federal income and excess profits taxes	$0.065	$0.905	$0.765

The Trade Commission's Report says:

In conclusion, the practical effect of governmental regulation of bituminous coal prices may be summarized as follows:

Furthermore, in considering future policy the past experience of the bituminous-coal industry should be considered.

It is highly desirable that definite up-to-date information be collected and made readily available for use. It is the opinion of the commission that the coal situation is so important and the knowledge of coal costs so essential to intelligent policy that some governmental body should be charged with the duty of regularly obtaining and promptly compiling current costs and average prices which would be available not only for the use of the Government, but also to all other interests involved —the operator, the miner, and the consumer.

Many attempts have been made to secure an insulating liquid which would not be combustible, and these attempts have mainly taken the form of the production

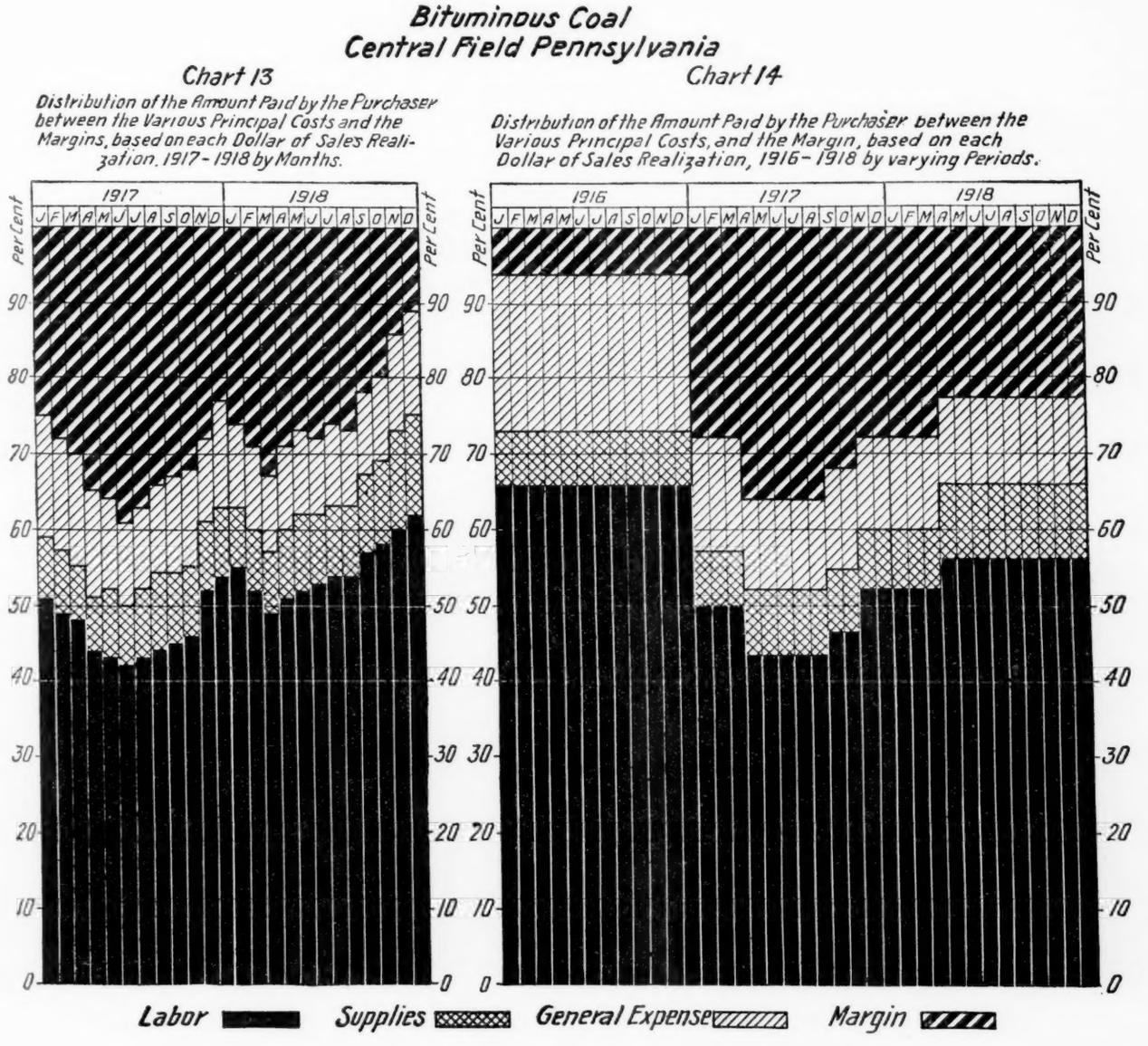


FIG. 2. DISTRIBUTION OF COSTS OF PENNSYLVANIA BITUMINOUS COAL.

In these two (the Southwest and the Central fields) Pennsylvania fields and for the country in general what governmental regulation of bituminous coal prices really did was—first, to check abnormal rise in prices, due to frantic bidding against each other by the consumers for an insufficient supply, and, second, to establish prices and maintain conditions which (after practically the entire output has come under regulation) allowed the operator margins materially lower than those prevailing for the preceding 12 months, though high enough to assure the increase in output which was vitally necessary to the successful prosecution of the war.

of a material in which the hydrogen of the hydrocarbon has been replaced by chlorine or a similar substance. Tetrachloride of carbon is satisfactory from some standpoints as an insulating liquid to replace transformer oil, but on account of the low temperature at which it boils, and on account of the physiological effect of the vapor on operatives, it has never made much headway as transformer insulation. Its production would make a notable advance in transformer engineering.

Rules for Boiler Inspection

By C. A. Allison

The following instructions are for the annual external and internal inspection of certain types of water-tube boilers:

Stop delivering coal to the boiler furnace that is going to be taken out of service.

Burn out the fire in the furnace as quickly as possible and close the damper. When the fire is out, close the boiler stop valve and notice if the auto-stop valve is tight.

Blow all water out of the boiler when the steam is down to 15 pounds.

Blow and clean off all soot from the tubes, superheater and headers.

Take off all handhole plates on the front header and manhole plates on the back of the steam drums. Inspect for leaky handhole plates on the back header; if any are found, remove them and put on new gaskets. All handhole plates on the back header are to be taken off and cleaned every two years.

Inspect the tubes inside the furnace for bags and blisters. If defective tubes are found, cut them out and replace by new ones; mark them when they are inspected.

Inspect all tubes internally for mud or scale. If scale is found, remove the handhole plates on mud drum and use a mechanical cleaner to remove the scale from the tubes.

Inspect the steam drums and water columns, and if scale or mud are found, wash out, clean and scrape.

Inspect the superheater and its connections to the steam drums, also inspect the baffle plates of the feed-water distributor and the dry-pipe for the outlet of steam.

After the scale or mud is removed from the steam drum, inspect the rivets and seams for corrosion, pitting or grooving of the steam-drum plates.

Inspect and clean the side walls, back walls and arches and back connections. If any defective brick are noticed, have them renewed or repaired.

Inspect the stoker and furnace grates; if defective, repair or renew defective parts.

Take down the steam gage and have it tested to read correctly; mark the date of the test on the gage.

Open the air vent on the steam drum and fill the boiler with water, taking notice while the boiler is being filled of any leaks and marking them.

After the boiler is filled with water up to the top of the steam drum, close the air-vent valve, and raise the water pressure to 100 lb. Then inspect the boiler for any leakage. If there is any leak that cannot be stopped while under a water pressure of 100 lb., remove the pressure and blow down the water so as to be able to stop the leak.

After attending to the leak, put the boiler under water pressure again at, say, 100 lb. for a start, inspect the boiler and if tight at that pressure raise the pressure to 200 lb. so as to be sure that the boiler is tight.

If the boiler is found to be water-tight under 200 lb. pressure, open the blowdown valve and remove the pressure from the boiler, open the vent valve on top of the drum and blow down the water until it shows one gage in the gage glass.

When the work herein outlined is completed, the watch engineer or boiler-room engineer is to inspect all apparatus and see that it is ready for service.

If everything is found to be in proper condition, close all doors, fill the stoker hopper with coal and start a slow fire.

When steam begins to blow from the vent pipe on top of steam drum, close the vent valve and allow the pressure to rise to 20 lb. When this pressure is obtained, blow out all water from the superheater, close the superheater valve and allow the pressure to rise slowly not to exceed 50 lb. per hour and allow the pressure to rise to within 5 lb. of the working pressure. When this pressure is obtained, open up the boiler stop-valve and connect the steam main and the boiler together.

After the boiler stop valve is opened up, the boiler is ready for service, and a regular fire is to be maintained in the furnace. The task of external and internal inspection is now completed.

Some Pointers on Flumes

By L. W. Wyss

There are natural soil or rock flumes which convey water to the intake racks and spillways of hydro-electric developments. The various artificial flumes can be classified as follows: Soil; soil with timber cribbing; soil with rock ripraping; soil with concrete lining or reinforcing; rock; rock with concrete lining or reinforcing; wood; and steel. Wood and steel flumes are sometimes supported by trestles and they are sometimes carried over valleys or streams on bridges.

Attention should be given to soil flumes to prevent cave-ins or washouts, which may slowly fill the flume or wash down the banks until considerable work is necessary in order to insure against complete destruction.

A growth of vegetation such as grass, clover or willows will help to retain the original embankment. Where small streams flow into soil flumes, they often carry considerable soil into the flume or wash the flume banks. This can be avoided by deflecting the small stream or arranging to carry the water to the flume in a trough or pipe.

At one place where an earth flume is in use, a soil diversion dam 10 ft. high and 280 ft. long was built about a quarter of a mile from the flume, and a hill was cut through in order to deflect a stream of water that flowed only in rainy weather.

Rock and concrete flumes require little or no attention, but it may be well to remember that where water pockets exist and are exposed to freezing temperatures, deterioration may result. Wooden flumes are, of course, preserved best when the wood is completely saturated.

Steel or iron flumes should not be allowed to rust until considerable scraping is necessary to remove the rust, as it is more economical to paint them often. Metal that is always submerged does not corrode so fast as that submerged only part of the time. Where flumes are supported by trestles, the foundation should be watched carefully, as settling might cause a leak that would undermine the flume and cause serious trouble.

There are, of course, many hydro-electric developments that are without flumes, having the intake screens and spillways located adjoining the reservoir. At such places little trouble is encountered with ice or river trash at the intake racks, because the velocity of the water is not great enough to prevent bypassing the trash with booms through trash gates. Also, in the winter time the low velocity prevents needle and anchor ice from forming before the river freezes, and this in turn prevents any floating trash from reaching the intake screens.

EDITORIALS

Unconscionable Profits

THE prosecution of Western oil producers on charges of profiteering has been ordered by Attorney General Palmer. Senator Capper says that they have increased their prices from about a dollar a barrel before the strike to four dollars and a half a barrel.

William G. McAdoo, former Secretary of the United States Treasury, says that in 1917 the mine owners made "shocking and undefensible profits" on bituminous coal. He saw their income and excess-profit tax returns. They showed earnings on capital stock, he says, ranging from fifteen to two thousand per cent. Earnings of from one hundred to three hundred per cent. were not uncommon.

The bituminous coal operators admit that profits were abnormal in 1917, but claim that the Government promptly put an end to them. How abnormal they were and how promptly the Government put an end to them is shown in the tables and charts reproduced from bulletins issued by the Geological Survey and the Federal Trade Commission on other pages of this issue.

Harry A. Garfield, Federal Fuel Administrator, says that the average realization upon 579,385,820 tons of bituminous coal mined in 1918 was $2.61 per ton; that the average cost of production during the same period was $2.15 per ton; that the margin of 46 cents per ton does not include interest charges, selling expense, Federal taxes, etc. The average income and excess-profit taxes for 1918 were upward of 30 cents per ton.

Hon. Carter Glass, Secretary of the Treasury, says:

> Coal operators generally in the United States in the years 1914 and 1915 lost money when normal depletion and depreciation are taken into consideration. What is meant by this is that a proper item in fixing costs is depreciation of plant and depletion of the cost or value of the coal in the ground.
>
> In the latter part of 1916 all coal companies in the United States, save those in the extreme West, began making money, with the result that the operations for the year 1916 generally show a profit of from 10 to 35 per cent. on capital invested.
>
> In 1917 all bituminous coal mines east of the Mississippi River made what might be termed fabulous profits, the general average being from 100 to 150 per cent. on invested capital, the range being from 15 to 800 per cent.
>
> In 1918 conditions were not so good in the Appalachian and central competitive districts, profits generally being reduced 25 to 30 per cent. less than for the preceding year, the range being from 15 to 300 per cent. on invested capital. In the West conditions in 1918 were better than in 1917, the profits in the Rocky Mountain Districts ranging as high as 400 per cent. on invested capital.
>
> Unofficial figures for 1919, incomplete of course, indicate the profits of the operators are less than for 1918, some of the operators claiming to have actually lost money.

J. D. A. Morrow, vice president of the National Coal Association, says that for the entire bituminous industry to make profits of from 100 to 150 per cent. would require a total profit of upward of $1,500,000,000. According to the United States Geological Survey Report, "Coal in 1917," he says that the total gross receipts of the operators for all the bituminous coal produced in 1917 was only $1,249,272,837. Hence he says the total gross receipts, before deducting operating expenses, were less than the alleged profits.

The total number of tons of bituminous coal mined in 1917 was 551,790,000. If the foregoing statement of gross receipts is true, the average selling price must have been $2.26 per ton.

The operators say that they will welcome the publication of "just as full current tax returns for the bituminous-coal industry as are published from any other industry," and Mr. Morrow requests Mr. Glass to "also publish for other industries their average percentage of profits both before and after Federal taxes have been paid."

District representatives of the United States Government filed in the Federal Court at Pittsburgh on December 8 a suit against the Transcontinental Oil Company, of that city, in which it is claimed that the concern had charged unjust and unreasonable prices for fuel oil. The allegation is made that the officials named sold fifteen thousand barrels of fuel oil for three dollars a barrel. Several other sales are cited.

Attorney General A. Mitchell Palmer says that up to the end of October, 1919, there had been ninety-two cases of seizure for profiteering in foodstuffs. In addition twenty-two instances of alleged hoarding have been reported and instructions issued to seize the goods and prosecute the offenders if the facts warrant such action. Approximately 4,800,000 dozen eggs, 1,700,000 pounds of butter, 2,500,000 pounds of meat and 20,000 cases of canned goods were included in these seizures.

Bradstreet's "index number" of commodity prices on December first sets the highest average prices yet recorded, and now stands at 131 per cent. above prewar levels.

The readers of *Power* are the largest purchasers of fuel. They are entitled to know the cost of its production and how that cost is made up: How much they are paying for the coal in the ground (the depletion charge) and how much the producers paid for it; how much profit it represents; how much they are paying the miners—for it is they who, ultimately, pay the miners' wages; how much interest they are paying on money actually invested, and what becomes of the difference between less than $2.50 per ton at the mines and the price at which coal is landed at the average power plant.

They are willing to pay a fair wage and a fair return to capital and enterprise, but no "unconscionable profits." Let us have the facts.

Accuracy at the Switchboard

TOO much stress cannot be laid on the necessity of accuracy at the switchboard in accomplishing successful, safe, efficient power-plant operation. Switchboard instruments, such as the synchronoscope, power-factor meter, wattmeter, ammeter, voltmeter, etc., are types of apparatus that are comparatively simple when understood in theory and operation, but may be so governed by conditions not immediately apparent as to confuse one who is not familiar with the instruments. The indications of such devices cannot always be taken at their face value; some thought must be given to all the conditions surrounding them and their connections and operation. There is a tendency among many operators

to familiarize themselves only with the purpose of the apparatus under their care, without interesting themselves in the theory of operation or the manner in which the various devices function; so that when some unusual or complex condition arises, for which a previous knowledge of their equipment would have prepared them, they misread the circumstances and commit some blunder.

Electrical machinery is no longer the "mystery" that it was some years ago, nor is the operation of it today the hit-and-miss process of old. Numberless books and papers are immediately available upon the appearance of each new device, and thereafter are continually added to. The operator of any device has the advantage over the designer of the equipment, in being able to continuously observe its operation; and the competent operator is the one who carries in his head, or at least in his notebook, every essential detail of all the apparatus in his care.

Beauty of design in the modern switchboard is not intended to be at the expense of utility. Such a simple device as the pilot light, with its shining gooseneck and green lampshade, may give a finished appearance to the switchboard; but the expense of its installation has not been fully justified if the location of the potential transformer, the primary and secondary fuses, and all the devices in the pilot-light circuit are not the intimate knowledge of the operator of that switchboard. The ammeter is intended to register the ampere load on the main circuit; yet the ammeter is only a part of an auxiliary circuit formed by the secondary winding of the current transformer, the current coils of the wattmeter and power-factor meter, and the circuit-breaker relay; furthermore, the position of the needle on the ammeter scale may not always be an exact indication of the ampere load on the main circuit. The capacity of a machine or cable, the setting of a circuit-breaker, the exact location and connections in the circuit of a potential or current transformer, or a control fuse, or synchronizing receptable—all these are details that many an operator has had cause to regret that he did not know.

Do Not Forget The Young Fellow

TOO often one is likely to forget that the engineers of tomorrow are the young firemen, cleaners and oilers of today. We do not want to preach a sermon; but we do not hesitate to remind our older readers, those in charge or in a position to help others, that it is just as truly their duty to give a lift to the progressive young men under them as it is to discharge their routine obligations.

Colleges may turn out a finished student, but none makes a pretense of furnishing the world with finished workers. To the young man who is not fortunate enough to have received a college education the places in which he is employed, if they are in his chosen field, are his school and his coworkers his teachers. To some few selfish, hairbrained individuals such ambitious young men are a joke and a nuisance, something to be fired out and replaced by the mediocre youth who will regard them as boss—and god. There are few such narrow men, but one finds one now and then. To the studious young man who has to tolerate such, we say get out; get away quickly though you have to owe a week's board to do so.

When one talks with men who have been successful, who have not hesitated to assist younger men to rise, he learns that the act of helping others is not only one of that man's great gratifications, but the spirit was one of the vital factors responsible for his own success.

There are many ways to help the young fellow who deserves it. Among the best is to promote him when he merits it and opportunity allows. This means that he should have the chance of familiarizing himself with the duties of the job higher up. In one of the most successfully conducted power plants—the Holtwood Station of the Pennsylvania Water and Power Co.—employees are required to know such duties as well as their own.

One of the fundamentals in the defunct Institute of Operating Engineers was that the power plants of its member engineers-in-charge should be schools for the younger men in so far as it was practicable. This plan is just as good as it ever was, whatever faults the Institute may have had—if, indeed, it had any. To adopt it in a plant might require procedure different from that necessary to successfully supply it in another; but it is one sound way of helping the progressive young man.

National Board of Boiler and Pressure-Vessel Inspectors

IN DISCUSSING matters pertaining to boiler legislation, *Power* has frequently voiced the opinion that there should be organized, as soon as a sufficient number of the states had established boiler-inspection departments, a national association of boiler inspectors, at which methods of inspection, the interpretation of rulings, the approval of specific designs and the respects in which experience shows revision of existing codes to be necessary could be discussed. Such an association was organized in New York on December second. Its membership is restricted to inspectors or other officials charged with the enforcement of regulations covering boilers and pressure vessels in cities and states which have adopted the American Society of Mechanical Engineers' Boiler Code. John F. Scott, of New Jersey, was elected chairman; James Neil, of Pennsylvania, vice chairman, and C. O. Myers, of Ohio, secretary-treasurer.

This society has a real mission, and as state after state realizes the importance of boiler legislation, and establishes boiler-inspection departments, we shall see it grow into a great national institution, whose task it shall be to reduce the industrial casualties from boilers and other pressure vessels to something like the proportions which exist in countries which have for years insisted upon a system of inspection which assures safe design, construction and operation.

The High Cost of Striking

W. D. McKINNEY, secretary of the Southern Ohio Coal Exchange, estimates that the loss to the United States on account of the recent coal strike amounted to about $126,000,000, of which about $60,000,000 consisted in loss of wages to miners and $40,000,000 of loss to railroads. Losses to industries shut down on account of fuel shortage are not included, and are not determinable, and so everybody is the poorer.

The La Salle is the only hotel in Chicago, if not in the country, that has lowered instead of raised its prices. This is the house in which the engineer, W. W. Bird, saved forty-five thousand dollars a year by reorganizing the power plant. They evidently have efficient heads of other departments.

CORRESPONDENCE

Sodium Bichromate in the Refrigerating System

In the Aug. 12 issue of *Power*, W. T. Meinzer states that in June, 1918, the United States Food Administration recommended the addition of one-half pound of sodium bichromate to each 100 lb. of aqua ammonia in the charge of an absorption refrigerating machine to prevent the formation of foul gas in the system and the corrosion of the pipes and tanks in contact with the aqua ammonia. He states that he put about 30 lb. of this chemical into the system under his charge and found that it prevented to a great extent the formation of foul gas, but that he wished to see the subject discussed in *Power*. He further stated that when washing out the machines he found a considerable quantity of black deposit in the generators, and that a sample of it analyzed by a chemist showed it to contain a large percentage of iron oxide. Here he found it necessary to renew 125 disks of valves on the generators, weak-liquor coolers, exchangers and other parts of the machine in contact with the aqua ammonia, but no renewals were necessary where only gas came in contact with these parts.

I advise Mr. Meinzer not to put sodium bichromate in the ammonia system and to use nothing but genuine wrought-iron pipe wherever the ammonia comes in contact with the piping; to use nothing but the best grade of ammonia and be sure it *is* the best; to put a vacuum on the absorber only when it is necessary; to keep the aqua pump rod in good condition and well packed. He, of course, has in mind that good ammonia quite frequently passes to the atmosphere around the rod, and that foul gas, water and air get into the system around the same rod. If I were in his place, I should send the entire charge of ammonia back to the manufacturer and have it rectified.

I should fill the entire system with distilled water that had been reboiled, and to this water I should add ¼ lb. of boiler graphite for each ton of refrigerating capacity. The water then should be heated to 180 deg. F. and the aqua pump started to circulate the distilled water and graphite through the system for six or eight hours, keeping it at a temperature of 180 deg. I should then draw out the water and refill with fresh reboiled distilled water and circulate it in the same manner until the system was clean. After this a clean charge of ammonia should be put in. Plenty of both aqua and anhydrous ammonia should be kept in the system and aqua should be kept out of the evaporator. The aqua should never be allowed to get below the coils in the generator. The generator should be large enough to do the work with not more than 15 lb. steam pressure. High-pressure steam means high temperature, and high temperatures always make foul gases in the refrigerating system.

As for the use of caustic soda in lime to prevent corrosion, it is my opinion that if the air can be kept out of the brine it will not be necessary to use the caustic soda; but if air is allowed to be drawn in with the brine through faulty pumps or agitators, trouble is sure to follow.

Winkelman, Ariz. GEORGE J. TROSPER.

Water Column Blowoff Valves

In the issue of Sept. 23, page 518, Mr. Noble and Mr. Jackson comment on the subject of water column blowoff valves and seemingly favor Mr. Cultra's idea. I am, however, opposed to it because I have had a few experiences that justify me in my stand.

Some years ago I was employed as a fireman in a paper mill that had been built to run by water power, but on account of dry seasons and an old and leaky dam, the power was inadequate and a 100-hp. engine had been installed to help out. The superintendent looked after the engine during the day, and at night the fireman took a squint at it once in a while to see whether it was smoking from lack of oil.

We had a 4-in. steam line branching out from the main line and leading to the paper machine. One night the inlet valve to the line began to leak around the stem, and one of the helpers got a wrench and tried to tighten it up, but only succeeded in making a bad thing worse, as the packing gland came out and also the packing. He sent a hurry call to me to shut off the boilers from the main line. Instead of doing that, I went upstairs and closed the valve to the 4-in. line, after which it was an easy matter to repack the valve stem.

Mr. Jackson claims that he has not yet found a globe valve the stem of which he could not pack while under pressure regardless of whether the steam was above or below the valve disk. He must certainly be a wizard, and I would like to be told in what way I should have proceeded in the event that the 4-in. valve had been so placed that the steam came on top of the valve disk.

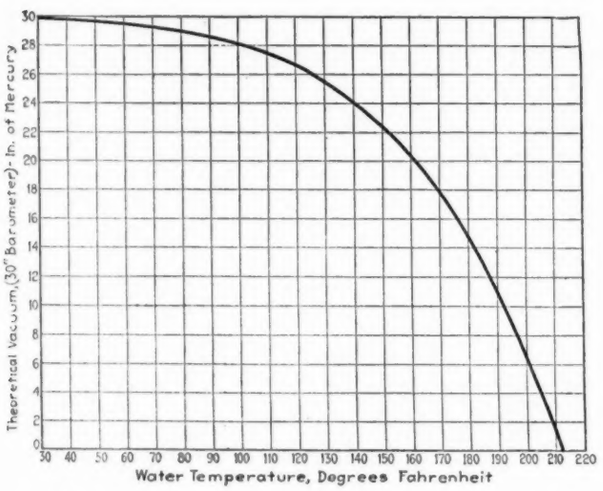
That a valve will close very tight with the pressure on top of the disk is true, as was proved to me very recently. We have a 160-hp. boiler, and in order to clean it it was necessary to have a small upright boiler to provide steam to run the pump that was used for flushing and also refilling the large boiler. On one occasion I had everything ready to start the pump and, as I thought, I opened the valve, but was surprised to find that with 60 lb. pressure no steam came through. Upon investigation it was found that the pressure was on top of the valve disk which had worked loose from the valve stem and was held firmly to its seat. That valve will never do that trick again. GUSTAV SWENSON.

Rockford, Ill.

Why Not Express Vacuum Values in Per Cent?

On page 396 of the Sept. 2 issue, Waldo Weaver advocates expressing vacuum-gage readings in per cent. of barometer readings. He very properly points out that the vacuum-gage reading means nothing, apart from the barometer reading, since the barometer varies widely at any one place, depending upon weather conditions; and under like conditions varies from place to place, depending upon altitude. Expressing vacuum as a per cent. of barometer is not, however, the logical solution of this difficulty. If it were possible for one to be inside the vacuum space of a condenser, he would be conscious only of the absolute pressure existing there. This pressure is fixed by the temperature of the cooling water, the amount of air leakage and the capacity of the vacuum pump. Outside atmospheric pressure has no influence whatever, except as it affects slightly the rate of air leakage. It seems unreasonable to express the record of pressure inside the condenser on the basis of atmospheric pressure, with which it is in no way connected.

The confusion so common in this connection arises from the available methods of measuring the pressure



CURVE SHOWING RELATION BETWEEN WATER TEMPERATURE AND THEORETICAL VACUUM

in a condenser or other vacuum apparatus. Such a pressure would be indicated directly by an ordinary barometer within the vacuum space, and there are on the market direct-reading absolute pressure gages based on this principle, but it is far more common to use a vacuum gage for this purpose. A vacuum gage, whether of the bourdon or mercury-column type, measures the *difference* between two pressures—the absolute condenser pressure and atmospheric pressure. Now the barometer reading is a measure of the absolute pressure of the atmosphere. Therefore, to get a true indication of conditions inside the condenser, we should subtract the vacuum-gage reading from the barometer, thus obtaining the absolute pressure within the condenser. The atmospheric pressure enters the problem, not because it has any logical or physical connection with the matter, but merely because it is a convenient datum from which to measure with simple instruments. Since it is itself variable, it must be eliminated by expressing the result in terms of absolute pressure. Doing this with Mr. Weaver's values and adding a column of absolute pressures to his table, we have the accompanying table. It is clear from this table that a given per cent. vacuum, as figured by Mr. Weaver, does not always correspond to the same absolute pressure.

VACUUM EXPRESSED IN PER CENT.
Average Values in Everyday Operation

Locality	Weather	Barometer, In. Hg.	Vacuum, In. Hg.	Vacuum, Per Cent.	Absolute Pressure, In. Hg.
New Haven Conn...	Fair	30.0	28.0	93.3	2.0
	Stormy	29.6	27.6	93.2	2.0
Dayton, Ohio.....	Clear	30.4	29.4	96.7	1.0
	Fair	29.3	27.4	93.5	1.9
	Stormy	28.9	27.4	94.8	1.5
Akron, Ohio.....	Clear	29.7	28.6	96.3	1.1
	Fair	29.1	27.2	93.5	1.9
	Stormy	28.7	26.8	93.4	1.9
Kansas City, Mo....	Clear	29.4	27.4	93.2	2.0
	Fair	28.7	26.8	93.4	1.9
	Stormy	28.3	26.4	93.3	1.9
	Clear	29.1	27.2	93.5	1.9

Suppose we consider a condenser having a fixed absolute pressure, while atmospheric pressure rises. If the barometer rises by one inch the vacuum gage also rises one inch, the absolute pressure remaining the same. To express this constant absolute pressure as a percentage of the varibale atmospheric pressure, to which it is in no way related, is no better than using the vacuum-gage reading directly. The case is much the same as though a man on an elevator were to measure the elevation of another elevator at lower level in an adjoining shaft. By dropping a tape to the lower car, he could determine the difference in level (the vacuum). This alone is useless, but if at the same time he notes the elevation of his own car above the bottom of the shaft (the barometer), subtraction gives him the elevation of the lower car (the absolute condenser pressure). To express the elevation of the lower elevator as a per cent. of that of the upper would give no definite idea of the location of either.

There is a method of expressing vacuum in per cent., which is used in connection with data concerning water-jet vacuum pumps. In such a pump the theoretically possible absolute pressure is limited by the temperature of the water supplied to the pump. Reducing this absolute pressure to vacuum referred to a 30-in. barometer (or to any other desired value) gives the theoretical attainable vacuum. Actual vacuum readings, referred to the same barometer reading, are expressed as a per cent. of this theoretical vacuum. The relation between the water temperature and the theoretical vacuum is shown by the accompanying curve. With an actual vacuum of 28 in., with water at 70 deg. F., we should have 95.7 per cent. of theoretical vacuum. With water at 90 deg., the very same vacuum would be 98.0 per cent. of the theoretical maximum. This method of expressing vacuum in per cent. of the theoretical maximum has some justification, since the theoretical maximum represents a real physical fact in the operation of water-jet vacuum pumps. It should be noted, however, that the per cent. of theoretical vacuum means nothing apart from the water temperature.

Indeed, vacuum alone, no matter how it may be expressed, requires other information to give it significance. If engineers would talk and think in terms of absolute pressure only, there could be no doubt of what is meant.

C. HAROLD BERRY.

Detroit, Mich.

In answer to Waldo Weaver's letter in the Sept. 2 issue, I think that there are at least two better ways to express vacuum, or pressure below atmospheric, than in per cent.: (1) Inches mercury absolute pressure; (2) inches vacuum at 30 in. barometer.

For quite a number of years I have handled correspondence in which vacuum is an important factor

This experience has led to the conclusion that one of the expressions cited, preferably the former, or its equivalent, is by far the most satisfactory and explicit way of expressing a vacuum condition.

Mr. Weaver is right in saying that "inches vacuum" is meaningless. An inquiry was once referred to me as to why only 20 in. vacuum could be carried in a machine which was designed and sold for operation at 28 in. vacuum (at 30 in. barometer). A little investigation showed that the machine was installed at an elevation at which the normal barometer is 22 in. and was, of course, operating at 2 in. mercury absolute pressure, as intended.

The expression "per cent. vacuum" has the same uncertainty, to a less degree, as "inches vacuum," but the possible error might still be serious. For instance, in the case cited, "90 per cent. vacuum" would mean to me at sea-level 27 in. vacuum at 30 in. barometer, or 3 in. absolute pressure, while the customer might have used 90 per cent. vacuum to mean $0.9 \times 22 = 19.80$ in. vacuum at 22 in. mercury, or 2.2 in. absolute pressure. The difference in the economy of the machine under the two conditions would be quite marked, and guarantees made under such a misunderstanding might cause the unnecessary loss of an order.

Expressions (1) and (2) are not so brief and easy to say as "inches vacuum" or "per cent. vacuum," but they have the infinite advantage, from an engineering point of view, of being exact and unmistakable—in a word, foolproof. My experience has taught me that it does not pay to use abbreviated expressions, as the slight saving of time or space is frequently offset many times over by the bother of straightening out a misunderstanding. It should always be remembered, particularly in engineering matters, that a certain combination of words may convey somewhat different thoughts to different people; therefore, the simplest statement can hardly be made too clear. It is often advisable to express the same thought in two different ways, as this method usually leaves no reasonable possibility of misunderstanding, even though either expression may be imperfect. For example, "28 in. vacuum or 2 in. absolute" leaves no doubt that the condition expressed is the same as 2 in. of mercury absolute pressure.

It is not my purpose to discuss here the effect of vacuum on the economy of the steam turbine, but Mr. Weaver's remarks on the subject impel me to say that his conclusions are contrary to my experience. Tests taken under my observation, by as exact methods as could be devised, show that a properly designed turbine will have its water rate decreased several per cent. for each inch of vacuum up to about 29½ in. at 30 in. barometer.

E. C. PERRY.

Lynn, Mass.

Would You Raise Your Pay If You Were Your Boss?

You know the fallacy of perpetual motion. You can't logically expect to get more out of a thing than you put into it. With 100 per cent. efficiency you can get out exactly what you put in, but no more. If one actually gets more than one is worth someone else is suffering for it and is getting less than he is worth.

Face the facts. How much revenue are you really producing for your employer? Are you turning out all the results possible in your working hours?

Some day just keep track of where the time goes. Divide the time into five-minute periods and make a note of when you start each piece of work and when you finish it.

Be honest about it. If you waste five minutes talking to the man across the way, put it down. If you lose fifteen minutes idly day-dreaming, while pretending to be engaged in deep thought, put it down, for this is to be a strictly intimate personal affair, and when it is completed you are likely to want to burn it up so that no one else will see it.

You will be surprised to see how much time has slipped through your fingers—time, the thing that once wasted can never be brought back.

After a while you will be able to judge yourself and your boss more accurately. You can then answer the question, "If I were my boss would I give myself a generous raise?"

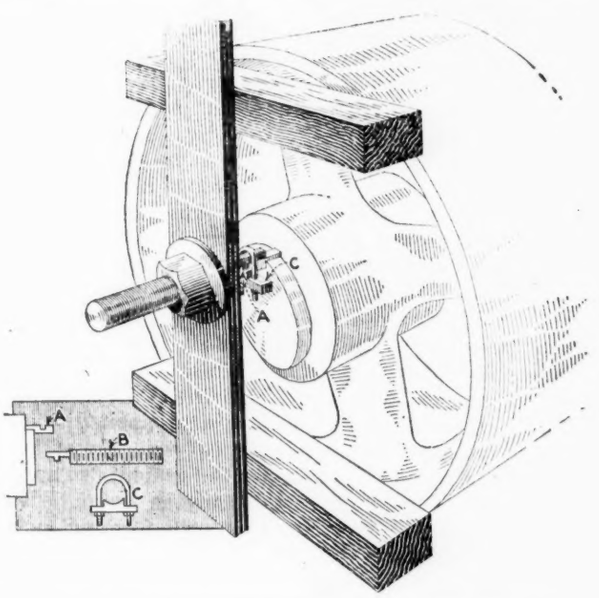
S. F. WILSON.

New York City.

Removing Heads from Motor Pulley

When it is necessary to remove a motor pulley it is frequently a difficult job to get the key out. The way some keys are driven it would appear that it was never intended that they should be removed. In taking off a motor pulley that resisted the usual methods, the following scheme was used:

The pulley was keyed to the armature shaft with a headless key extending about an inch from the end of



KEY-PULLING DEVICE; PARTS AND ASSEMBLY

the shaft. The original key must have become loose, allowing the pulley to work off, but whoever put this one in intended it to stay there, as it showed all the signs of having been driven home for keeps. With a hacksaw blade bent inside the pulley, a rough notch was cut in the key about ¼ in. from the end, as at *A*. Then a ⅝-in. bolt was ground and filed flat at the head end, leaving a projection to fit the notch in the key, as at *B*. By using an ordinary cable clamp, shown at *C*, borrowed from the elevator operating cable, the bolt and key were clamped securely together. A piece of flat iron with a hole bored in it for the bolt was placed over the end of the pulley on wooden blocks, as shown in the figure. A nut was then screwed down on the bolt against the iron, and in this way the key was easily removed, after which the pulley was taken off without difficulty.

H. WILSON

Toronto, Ont., Canada.

Boiler-Tube Failures

I read with interest the letter by Waldo Weaver on "Boiler-Tube Failures," page 887 of the June 10 issue of *Power*, also the later articles on the same subject. There are many good points in these articles, and I believe a discussion of the advantages and disadvantages of the different methods of scale removal and prevention will be of interest and value.

Mr. Applebaum, page 477, of the Sept. 16 issue, seems to be partial toward lime-water softeners. While this is one of the logical methods of keeping boilers clean, the first cost of such equipment has proved prohibitive in the majority of average-sized plants. In some cases water softeners cannot be used, or when used are only from 50 to 75 per cent. efficient, as in some waters the scale-forming matter can be precipitated only by being subjected to very high temperatures. Therefore most water softeners would be of little or no use where such conditions prevail.

Warren D. Lewis, in the same issue, favors the graphite treatment. "The doses to feed boilers advocated by manufacturers of this product are intended to get the scale out of a boiler in 'jig' time, and they usually do," he says. This statement called to mind an experience while visiting a certain city recently. In passing the plant of a manufacturer of graphite, my attention was arrested and my curiosity aroused by hearing the unmistakable sound of a boiler-tube turbine cutting through hard scale. As the window was open in the boiler room, I looked in and, as I expected, saw a man turbining a water-tube boiler.

In view of the foregoing, I would like to ask Mr. Lewis if, as he states, graphite will remove scale in "jig" time, why is it necessary for the manufacturer of this product to turbine his own boilers?

Although I do not agree that graphite is a scale remover, it has been my experience that coating the inner surfaces of tubes and headers with a thin coat of graphite is good practice. This can be done with a swab attached to the end of a length of $\frac{3}{8}$- or $\frac{1}{4}$-in. pipe. I have found this practice, when applied to clean boilers, to delay considerably the formation of scale. But in time it will be found that the graphite so applied will be washed off by the action of the water, leaving the surfaces bare; then any new scale-forming matter coming in contact with these surfaces, will bake on, forming scale. In my opinion, based on close observation in practice, after the scale has started to form no amount of graphite introduced with the feed water will remove the scale already in the boiler or prevent the majority of new scale from forming.

I believe that (disregarding water-softening systems that remove most of the impurities from the water outside of the boiler, as most engineers must disregard them as unattainable), the logical way to keep boilers clean is to use some form of mechanical treatment that will precipitate all scale-forming matter in the form of sludge. Then, if the boilers are blown down at regular intervals, the surfaces can be kept clean without difficulty.

I do not favor the chemical treatment of water inside of the boiler by means of present-day compound, as I do not think the amount of compound recommended is strong enough to treat the large volume of water. To a 100-hp. boiler operating ten hours per day, for instance, it is usually recommended that one gallon, or less, of compound be used. Let us assume one gallon of compound weighs ten pounds. A 100-hp. boiler will evaporate 3750 lb. of water, from and at 212 deg. per hour, or 37,500 lb. of water for a ten-hour run. According to this it will be necessary to feed one ounce of compound to each 6000 lb. of water. In other words, this would amount to a $\frac{1}{96,000}$ solution, which is very weak.

The foregoing theory, of course, has been expounded before, among other manufactures of a few boiler treatments that are claimed to prevent the formation of scale by coating the inside of the boiler. This coating, being smooth, is supposed to prevent the adherence of scale-forming matter.

Now the question arises, What is to prevent the latter-mentioned treatment from forming so thickly that it would retard the transmission of heat to such an extent that it would be as bad as a coating of scale? Even though it is a conductor of heat, as is claimed, this is possible. Boiler iron is as much a conductor of heat, I believe, still it has been ascertained that 10 in. of boiler iron, 1 in. of scale or $\frac{1}{10}$ in. of oil offers equal resistance to the transmission of heat. Would it then become necessary to turbine the boilers to remove the excess material? Or would it be possible to remove it by turbining?

All engineers are agreed on one point, however—that to maintain the highest efficiency it is necessary to keep all boiler surfaces clean. They differ only in the means of attaining that end.

I recently had occasion to investigate the claims of a manufacturer, of a process designed to keep the boiler surfaces clean without turbining by precipitating the scale-forming matter in the form of sludge. This process is purely mechanical in its action. The preparation used is composed principally of aluminum oxide and aluminum phosphate, the soda content being but 1.09 per cent. The aluminum oxide and phosphate being insoluble in either hot or cold water, are kept in constant agitation inside the boiler by the circulation of the water. These particles in constant agitation come in contact with the minute particles of scale-forming matter as soon as such matter starts to adhere to the boiler metal, wiping the particles off and precipitating them in the form of sludge. For oil this material seems to have an affinity, as it absorbs or unites with it, causing it to settle in the mud-drum, from which it can readily be removed by the regular use of the blowoff valves.

With this method of treatment it can be readily seen that no variation in the chemical composition of the feed water can affect the results.

Brooklyn, N. Y. EUGENE TOUSSAINT, JR.

Brasses Improperly Fitted

I had trouble with an engine some years ago as follows:

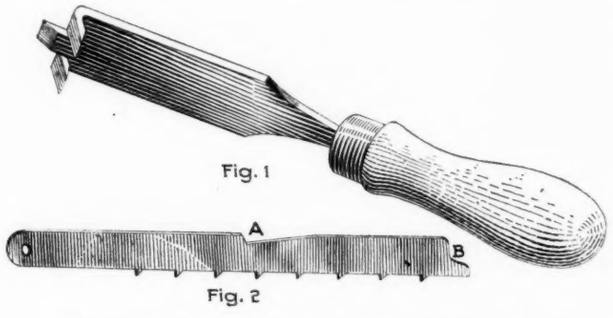
The wristpin bearing would wear so fast that it had to be taken up about three times a week. After carefully fitting the brasses to the pin and determining that the valves were properly set, I still had the same trouble, but one day while holding my hand on the head-end brass I found it to be slightly loose and working in the strap, owing to an improper fit. After this was properly fitted, there was no further trouble with the engine.

White Plains, N. Y. JOHN W. HILFRANK.

Removing Retaining Wedges and Coils from Induction Motors

In the Aug. 12 issue of *Power*, W. J. Hohe asked for some suggestions on how to remove retaining wedges and coils from induction motors. The operation is usually attended with some little difficulty and requires considerable skill and patience at times, in order to prevent damage to the windings.

Metal or fiber retaining wedges can generally be knocked out easily enough by means of a steel drift having a blunt nose. Tapping the surface of the wedge sharply with a hammer and fiber drift helps to loosen and makes the wedge drive easier. The same method is applicable to wooden wedges, but is not always successful, as a very tight wedge will spread at the end or perhaps split. A driving tool fashioned from an old 12-in. hacksaw blade, Fig. 2, will be found useful in obstinate cases. Grind off most of the teeth, leaving about eight toward one end, about one-half inch apart. Striking an oblique blow at *A* and *B* forces the teeth into the wedge and provides a larger area of contact for the purpose of driving out. When it is necessary



FIGS. 1 AND 2. TOOLS FOR REMOVING RETAINING WEDGES FROM STATOR SLOTS

to cut out a wedge, the tool shown in Fig. 1 will be found useful. It can be made from an old flat file or wood chisel. The shoulders rest on the top of the slot and when held at the proper angle the tool will cut the center of the wedge out, without cutting through into the coil; the remaining pieces may then be picked out.

In order to replace the damaged coils of an armature or stator, it is necessary to raise one side of the coils which overlap the one to be removed. With the open-slot type of winding the first coil is the hardest to lift without damage to the insulation. A good method for a tight job is as follows:

Take two pieces of strong, thin leather about eighteen inches long and one inch wide (heavy duck cloth, doubled and stitched will do) and rub them with soapstone or wax. Separate the coil to be raised from the others by means of small wooden wedges. Place the tape through the coil at the end of the winding and work it up to the end of the slot. A strong pull will then generally do the trick. With this coil up, the tapes are more easily applied. Lifting tools as described on page 467 of the Sept. 16 issue can also be used to advantage. The frame should be heated if the insulating cells stick to the sides of the slots.

The semi-closed slot machine is more difficult to handle, and when the impregnating varnish or compound has lost its life and become hard and brittle owing to overheating, it is practically impossible to raise the wires out of the slots without peeling the insulation. In such a case it is advisable to rewind the whole machine. Where there is only one coil in each slot, an emergency repair may be made by pulling in one or more coils without raising the span. When the compound is in good condition, heat applied to the frame, either in an oven or by current from a suitable low-voltage transformer, will tend to prevent the insulation peeling. To remove a coil strip or cut the covering tape to well behind the turn of the coil, loosen the wires outside the slot with a sharp fiber wedge and lift out one at a time. Try to prevent kinks and arrange the wires symmetrically so that they may be replaced in approximately the original position. Without care in this respect, it may be difficult to get all the wires back into the slot without abuse.

H. WILSON.

Toronto, Ont., Canada.

Why the Arrow on Belting?

In the Sept. 16 issue of *Power*, page 473, a correspondent asking Why the Arrow on Belting? has analyzed a belt problem under traditional installations, methods of care and treatment. If the salient features of the drive are as correctly analyzed as in the article in question and a belt selected to meet the requirements of the drive, there need be no allowance made for slip with subsequent proper care and treatment, unless there is a sudden great increase of load or frequent starting of loaded machines.

Under these conditions slip is expected to relieve a danger, which is one of the many good features of belt transmission. Under normal conditions slip and creep should not exceed 2 per cent. A larger average loss than this indicates a wrong that can and should be corrected.

Manufacturers of good leather belting, knowing these facts, place the arrow on the belt to indicate the direction in which the belt should run to give the greatest service—which is the measure of the belt's value.

Slipping belts and tight belts steal power, waste time, give inefficient service and are never far from the scrap heap.

J. FRED ENGLER.

Tyrone, Penn.

Frost on Compressor Suction Line

In the Aug. 12 issue, under "Inquiries of General Interest," was an item on the frosting back of the suction pipe to the ammonia compressor. The advantage gained by having frost on the suction pipe back to the compressor is that the lower the temperature of the gas the less volume it requires in the compressor per pound; consequently, the compressor can run slower for a given capacity. The frost on the suction line indicates that the gas passing through it is 32 deg. F. or lower. To operate a compressor efficiently, the suction gas should be as nearly saturated as possible. But to prevent the gas from becoming supersaturated, four or five degrees superheat should be carried. With a suction pressure of 15½ lb. gage the temperature of the ammonia is zero degrees F., and it should enter the compressor at this temperature plus this four or five degrees superheat; but it should never be above 10 deg. F. on entering the compressor on 15½ lb. pressure.

The greater density of the compressor suction gas is not the only advantage of having a frosted suction line. There are many. However, a frosted suction line is not by any means an efficient one, although a suction line heavily covered with frost is an indication of good operation.

GEORGE J. TROSPER.

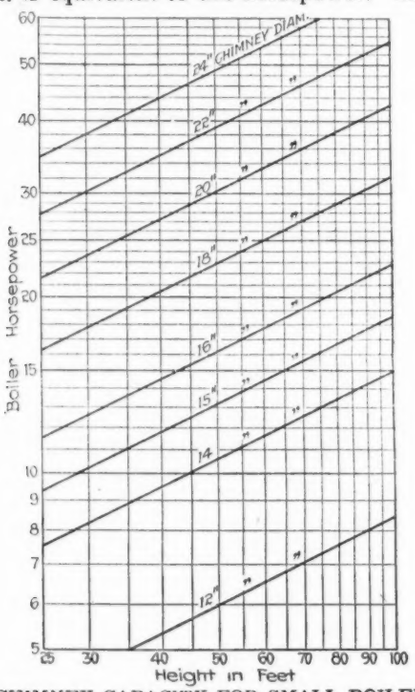
Winkelman, Ariz.

Chimney Capacities for Small Boilers

Some years ago *Power* published a chart by W. L. Durand from which could be determined the capacity of any chimney from 50 to 400 ft. in height and from 15 in. to 102 in. in diameter. The capacities ranged from 20 to 2000 hp. While the field covered by that chart included practically every necessity of the small and medium-sized power plant, it was hardly useful for the small heating installation.

The accompanying chart is also plotted on logarithmic paper from the Kent formula $Hp. = 3.33\ (A - 0.06\ \sqrt{A})\ \sqrt{H}$ and determines the capacity of chimneys from 25 to 100 ft. in height and from 12 in. to 24 in. in diameter. The capacities range from 5 to 60 hp. In Kent's formula, A is the area of the chimney in square feet and H is the height in feet.

In using this chart it should be remembered that cast-iron boilers are generally overrated, and therefore the size of the stack should be determined from the number of square feet of direct radiation actually installed. For example, a building requiring 2000 sq. ft. of direct radiation to maintain an inside temperature of 70 deg. would require a cast-iron boiler rated at 3000 to 3200 sq. ft. As a square foot of direct radiation normally condenses ¼ lb. of steam per hour, theoretically 138 sq. ft. is equivalent to one horsepower. In practice



CHIMNEY CAPACITY FOR SMALL BOILERS

it is usual to assume 100 sq. ft. as equivalent to one horsepower, which allows for losses in piping, etc. It is important to note that this applies only to *normal* conditions. If direct-indirect or indirect radiation is used, it must be resolved into equivalent direct radiation. Moreover, unusual conditions of temperature must be taken into consideration.

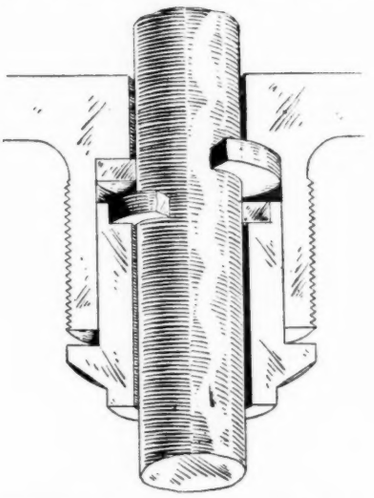
This chart can also be used on a hot-water job by multiplying the number of square feet by the B.t.u. emitted per square foot per hour and dividing by 33,482 —the result being the horsepower. For normal conditions 75 per cent. of the total hot-water radiation will be the equivalent steam radiation, and the latter divided by 100 will give the horsepower.

New York City. HENRY P. KAHN.

Worn Plungers Caused Packing Trouble

A second-hand vertical four-plunger single-acting pump, installed to furnish 3000 lb. hydraulic pressure in a clay-working plant, gave an extraordinary amount of packing and valve trouble.

The plungers had to be packed three or four times a day as the packing would get chewed up, pull out through the stuffing-box glands, work back around the plunger into the pump chamber, and get under the valves and hold them off the seats enough to allow them to begin grooving. Then there was nothing but to shut down, repack plungers and regrind valves.



BUSHED STUFFING BOX AND GLAND

It was determined that the plungers, being badly worn, were the cause of the trouble, and new ones were ordered from the pump manufacturers. It would be some time, however, before the order could be filled, and in order to keep going without the annoyance and expense of continually repacking, the tool-steel plungers were taken out and turned down until straight.

This made the plungers considerably smaller than the holes in the stuffing-box gland and the bottom of the stuffing-box. In order to overcome this difficulty, brass rings were turned to a close fit for the bottom of the stuffing-boxes and bored a close fit on the new size of the plungers. A similar ring was made to go on top of the packing, but it was found that it was hard to remove when repacking, so it was removed and the old glands were taken out and bored for about five-eighths of an inch in the bottom and a brass ring driven in. In this way the top ring always came out with the gland. With these repairs, as shown in the illustration, the pump was run successfully until the new plungers arrived.

Cherryvale, Kan. EARL PAGETT

Maple Charcoal Not Good Filtering Medium

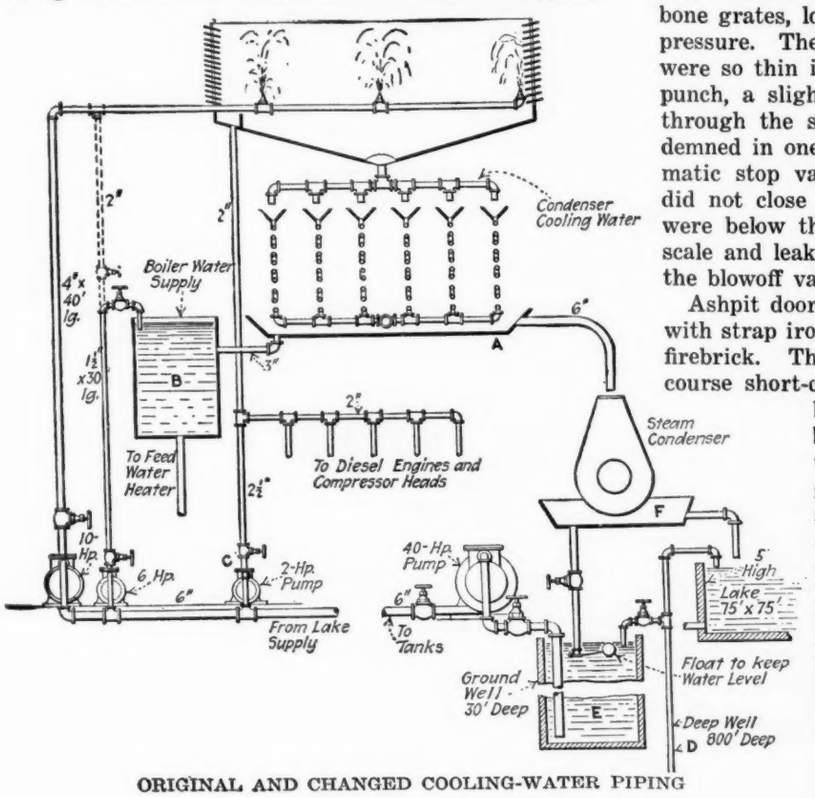
Some years ago on putting in service an ice plant located near New Orleans and using distilled water, we had considerable trouble with black specks in the ice. Mississippi River water was used and filtered through maple charcoal. In the midst of our troubles a fireman from a neighboring plant came in and, after inquiry, advised us that the charcoal was the cause. A change to bone was made, and the specks no more appeared.

San Francisco, Calif. O. JASON.

Changed Ammonia Condenser Piping

When a plant has been gradually enlarged, first by one engineer and then by another, the probabilities are that changes can be made that will effect a saving in operation. The original cooling-water piping of a certain plant is shown by the continuous lines in the accompanying illustration. The changes and extensions made are shown by the dotted lines.

The pipe-line connection between the ammonia condenser pan *A* and the boiler feed-water tank *B* enables the cutting out of a steam-driven pump, making a considerable saving in steam. The water from the condenser is also warmer than the lake water, and owing to a water-heating system much of the water scale is left at the condensers instead of in the boilers. The steam pump is now held in reserve to pump water to the condenser coil in case the main pump fails. By extending the cooling-water system to the roof sprays, cooling water to the different unit heads is supplied from above also, thereby discontinuing the use of the 2-hp. electric-driven centrifugal pump *C*.



ORIGINAL AND CHANGED COOLING-WATER PIPING

Originally, the water was lifted from the deep-well supply *D* into the ground well *E*, and from there it was lifted by a 6-in. centrifugal pump to two railroad water tanks. By piping direct from the deep well into the lake, the cool water from the well could then be used over the condensers. Also, by connecting the steam condenser pan *F* to the ground well *E*, a considerable amount of hot water was taken out of the system and pumped to the railroad tanks. This change lowered the discharge pressure of the refrigerating machines from 210 lb. to 190 lb. The cooler water also condensed more exhaust steam, thereby saving a small amount of live steam. Then by installing a float-valve on the discharged end of the pipe from the steam condenser a constant water level is obtained in the ground well, which saved the extra average 15-ft. lift for the water pump to the railroad tanks.

The total cost of these four connections was approximately $60. The total estimated saving per month is $300. With the steam pump and small electrical centrifugal held in reserve, and the lake water to serve the railroads in case the deep well fails temporarily, the engineer in charge has a twofold safety factor, which means much in production.

W. A. DARTER.

Brenham, Tex.

Mismanagement of Boilers

Of all the prizes ever drawn in power-plant management it is the belief of the writer that this is the star. I was instructed to inspect the boiler room of an Atlantic coast hotel which was commandeered for the purpose of remodeling it into a hospital for convalescing soldiers.

There were two Stirling boilers, hand-fired, herringbone grates, low setting, rated at 150 hp. at 150 lb. pressure. They were set in 1909. The boiler tubes were so thin in places that, when applying a center punch, a slight hammer blow sent the punch clean through the side of the tube; 54 tubes were condemned in one boiler and 29 in another. The automatic stop valves did not work because the disks did not close down on their seats. Blowoff valves were below the floor level in a pit, encrusted with scale and leaking. There was no plug-cock between the blowoff valve and the mud drum.

Ashpit doors were cracked and had been repaired with strap iron. Lost baffles had been replaced with firebrick. This baffling was not cemented and of course short-circuited the gases flowing around the baffling. The water columns were in a leaky condition, gage-glasses were milky with scale, gage-glass fittings were green from the chemical action of the scale and water, try-cocks were missing on one of the water columns and those on the water column of the second boiler were too full of scale to permit lifting by hand. Insulation on all piping had entirely disappeared. The glass faces of the steam gages were missing, and water leaking past the dials indicated the need of new gages.

The top of the windbox of the blower formed the bottom of the ashpit. This forced ashes over the front of the mud drum when the draft was on. Ash handling was difficult because the floor of the boiler room was four feet below the street surface. A water meter was set at the entrance of the boiler room between the boilers and the door. Thus ashes had to be handled twice.

The exhaust from the steam engine was piped inside of the chimney to the top instead of passing through the feed-water heater. The heater drew live steam from the boiler to heat the feed water. The water-pump follower rings were cracked and the piston scored, but it managed to feed "some" water to the boiler. Engine crosshead guides had to be rebabbitted as they had been running iron-to-iron. The top of the frame was cracked but had been oxyacetylene-welded. Both cylinder and piston were scored, the packing worn and loose, the Corliss gear out of alignment and knocking, and the valves were not set for proper lap and lead.

The separator insulation was missing and the drainage plugged. No trap had been provided to catch the drain from the separator.

Investigation of the water conditions disclosed the fact that at certain times salt marshes would overflow into the wells and no further attention was paid to this water as far as chemical analysis was concerned. The result is apparent. S. ROSENBERG.

New York City.

Repairs to a Steam Turbine Governor

The following account of an accident and repair to the governor of a steam turbine may be of interest to *Power* readers.

The machine is a Curtis Horizontal, 500-kw. 3600 r.p.m. In some manner, probably in stopping, one of the dogs controlling the opening of the steam valves became hooked up on the shield-plate cap and reciprocated the whole governing mechanism, all working with the steam arm. Later in the day, when the operator on watch went to put the unit in service, the accident was discovered. The dog was released and the machine tried again, but it refused to open the steam valves at all.

The first impression was that the spindle at the top of the governor had broken or become loose, and it was examined and found to be all right. Next, the plate on top of the governor weights was removed and the two transmission links taken out and examined, but they appeared all right excepting that the top bearing of one of them was badly worn. It was reasoned that this was hardly the cause of the trouble, for the wear had been six years taking place and the governor had been functioning perfectly. Nevertheless the hole was bushed, and a slight improvement was noticed, but still it was a long way from being in a satisfactory condition.

The operating crew was by this time "up a tree," the day being Sunday, and the unit had to be in service the following morning. The whole outside mechanism was gone over thoroughly, and nothing was found out of adjustment, broken or bent. The reciprocating of the governor parts, through the shield plate, governor connecting-rod and lever, to the links, put a severe strain on the links; as it was discovered, on trying with a bar, that it moved the governor weights out against the tension of the spring. At the same time there was nothing to show any derangement.

The transmission links are two small pieces of about ⅜-in. mild steel curved to a certain form, and it was decided they had straightened out under the strain referred to. They were taken out again and bent a little more, put back, and the machine given a trial. The improvement was enough to convince us that we were on the right track, so the turbine was stopped, the links again taken out and given a little more curvature. On another trial the valves all picked up on starting, and closed at the right time as the machine came up to speed, proving that we had located and removed the trouble.

The puzzling feature of the case was that there was no indication as to what the trouble might be, as there was nothing apparently out of place. The remedy was arrived at by a process of elimination and deciding what was the weakest place that might give way under the excessive strain. J. A. WATKINS.

Jefferson City, Mo.

Repairing a Grounded Commutator

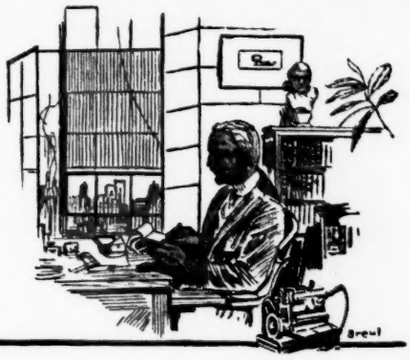
The method I used in repairing a grounded commutator may be of interest to *Power* readers. The ground was caused by the mica end ring breaking down on the outer end of the commutator. Before the commutator was opened for repairs, it was thoroughly cleaned with gasoline and an air blast. The commutator and shell were then heated so that the shell and the mica end ring could be removed without breaking the mica. As the coil leads were not removed from the bars, there was no need of clamping the commutator to prevent it from pulling apart. After removing the end ring, the inside of the commutator was thoroughly cleaned and painted with a commutator-insulating varnish. A new segment of sheet mica was cut to shape, using as a templet the old segment, which had been injured when the breakdown occurred. The inside edge of the mica alone was cut to size, the outer edge being left large, so that it could be turned off after assembling the commutator. The new mica segment was varnished on both sides and set in place. A patch was then put on the mica end ring by setting in two pieces of sheet mica 0.03 in. thick in such a manner that the joints were in no place nearer than ¼ inch, as shown at *A* in the figure. When reassembling the commutator, it was not necessary to give it a complete baking, as but a very small part of the mica was renewed. While hot the shell was drawn as tight as possible, and when the commutator had cooled it was turned and polished. A ground test with 1500 volts was made for one minute on the commutator without its showing any ill effects. R. L. HERVEY.

MICA "V" RING SHOWING HOW THE REPAIR WAS MADE

Washington, D. C.

The electric furnace used in the steel industry is of comparatively recent introduction. There are, however, over 800 of the furnaces in use at the present time, 300 of which are in the United States. The latter have all been installed during the last ten years.

INQUIRIES OF GENERAL INTEREST



Relative Cost of Water Supply by Air Lift—We have a well 700 ft. deep and, when previously used, the water supply was limited only by the capacity of the air-lift pumping equipment. Our boilers are operated at a cost of 32 cents per 1000 lb. of steam generated. Would it pay to resume operation of the air lift as against purchasing city water at a cost of 10 cents per 100 cubic feet? T. H.

An estimate of the probable efficiency of the air lift cannot be made without taking into account the depth of water standing in the well while pumping the required quantity of water, amount of submergence of the air pipe, the character of compressed-air equipment and amount of water required. With ordinary air-lift efficiency and neglecting extra labor and first cost under the conditions that are stated, the cost for operating an air lift should not exceed 75 per cent. of the cost for a city water supply.

Motor Overloads Generator—We have a 150-kw. direct-current 500-volt generator that supplies power to a 100-hp. motor. When the motor is started with no load, it takes from 240 to 260 amperes and causes the voltage to drop from 500 down to about 400. The starting box is rated at 100 hp., 500 volts and 160 amperes. I would like to know how to overcome the above trouble. J. F.

Where a 100-hp. motor is started from 150-kw. generator you may expect to have more or less trouble with voltage regulation. The current taken by the motor at starting is not excessive. However, since, as you state, the motor is started light, no doubt it can be started with the resistance increased about 100 per cent. in the starting box. This would reduce the starting current to about 120 or 130 amperes. If the motor is never started under full load, there is no doubt that a 50-hp. starting box would have sufficient capacity to take care of the motor, and this would cut the starting current in about half. You might make up a temporary resistance from some iron wire and connect it permanently in series with the armature lead with a single-pole switch, so that after the starting-box resistance has all been cut out the single-pole switch can be closed, and cut the temporary resistance out of circuit. Or you may make up a water rheostat and connect that in series with the armature circuit. On starting the motor, first bring the arm on the starting box over to the running position and then bring the electrodes together in the water rheostat. Of course the movable electrode of the water rheostat will have to be brought in contact with the solution before the starting-box arm is placed on the first contact or the motor will not start.

The poor voltage regulation experienced may be due to the governor on the engine being sluggish, or the series-field winding on the generator may be connected in opposition to the shunt-field windings. It would be advisable to make sure that the governor of the engine is in good working condition and then cross the series-field winding to see if this will give better voltage regulation. The regulation will either be materially improved or made worse; if the latter, put the connection back to the original arrangement.

Size of Delivery Pipe for High-Head Waterwheel—Where there is an ample supply of water, what size of pipe line 600 ft. long would be required for delivery of sufficient water to a turbine waterwheel under a gross head of 400 ft. for the development of 50 hp.? J. M.

Allowing 75 per cent. efficiency, "the power in the water" delivered at the waterwheel would need to be $50 \div 0.75 = 66\frac{2}{3}$ hp. or $66\frac{2}{3} \times 33{,}000 = 2{,}200{,}000$ ft.-lb. per min. Where l = the loss of head in feet due to pipe line friction, $h = 400 - l$ = the net or effective head in feet of the water as used at the wheel, then the flow of water per minute would need to be $\frac{2{,}200{,}000}{h}$ lb.; or $\frac{2{,}200{,}000}{h \times 62.4} = \frac{35{,}256}{h}$ cu. ft., or $\frac{2{,}200{,}000}{h \times 7.48} = \frac{294{,}118}{h}$ gal. per min.

By referring to tables giving loss of head per 100 or per 1000 ft. length of pipe of various sizes for different rates of flow and bearing in mind that for a given size of pipe the loss of head from friction is directly as the length, assume different values for l and find the smallest pipe that will deliver $\frac{35{,}256}{h} = \frac{35{,}256}{400 - l}$ cu. ft. per min., or $\frac{294{,}118}{h} = \frac{294{,}118}{400 - l}$ gal. per min.

If 5 per cent. of the total head is lost in friction, then for $l = 600 \times 0.05 = 30$ ft., or $30 \times \frac{1000}{600} = 50$ ft. per 1000, the flow would need to be $\frac{294{,}118}{400 - 30} = 795$ gal. per min.

With a loss of 40 ft., or $40 \times \frac{1000}{600} = 66.6$ ft. per 1000 the flow would need to be $\frac{294{,}118}{400 - 40} = 817$ gal. per min., and with a loss of 50 ft., or $50 \times \frac{1000}{600} = 83.3$ ft. per 1000, the flow would need to be $\frac{294{,}118}{400 - 50} = 8.40$ gal. per min.

Referring to Weston's Tables of "Friction of Water in Cast-Iron Pipes" (which for all practical purposes may be assumed to be applicable to steel or wrought-iron pipes), it may be seen from the table that a 4-in. pipe would have insufficient capacity with any of the assumed losses of head. With a 6-in. pipe it may be seen that a discharge of 800 gal. per min. corresponds with a loss of 59.48 ft. of head and a discharge of 8.25 gal. per min. corresponds with a loss of 63.25 ft. of head, the average of these values giving 812.5 gal. per min. for 61.36 ft. per 1000, or $61.36 \times \frac{600}{100} = 36.8$ ft. loss for 600 ft. of 6-in. pipe.

Substituting 36.8 for l in the expression $\frac{294{,}118}{400 - l}$ shows that for 36.8 ft. loss of head, or $400 - 36.8 = 363.2$ net head, the demand would be $294{,}118 \div (400 - 36.8) = 810$ gal. per min., or less than 1 per cent. below the computed average discharge.

Fuel-Oil Papers at Philadelphia Engineers' Club

THE interest that fuel oil has created along the Atlantic Coast was well indicated Thursday evening, Dec. 11, when two papers were given on the subject at a combined meeting of the American Society of Mechanical Engineers and the American Society of Heating and Ventilating Engineers at the Engineers' Club, Philadelphia. Henry Thomas, combustion engineer, of the Sun Co., dealt with the production and commercial end, while E. H. Peabody, of the Babcock & Wilcox Co., New York, discussed the subject from the standpoint of the consumer. The hall, though not a large one, was so crowded that many of those in attendance sat in the aisle on the floor, and when this became full, the back of the hall was jammed with those who were standing.

Mr. Thomas' Paper

Mr. Thomas began by dwelling upon the historical aspects of the subject, stating among other things that Pennsylvania rock oil was found in 1854 and that in 1859 the first oil well was drilled in Pennsylvania, yielding 25 bbl. a day and continuing in operation for one year. The yearly production in 1859 was about 2000 bbl. According to the Geological Survey, he said, the world's petroleum production for 1918 was 514,208,718 bbl. and the production for the United States was practically 355,000,000 bbl. Pennsylvania wells, he said, ranged in depth from 200 to 1000 ft., a few going considerably deeper; the Mid-Continent wells from 1500 to 1900 ft.; Gulf, from 800 to 900; California, 2000 to 5000 ft., and Mexican wells, from 1000 to 2500 ft. He then described the systems of drilling wells. Considerable gas pressure is invariably met with in wells, running from 800 to 1000 lb. per sq.in., which acts to gush the oil from the well. When sufficient gas pressure is lacking, the wells are frequently torpedoed to start the flow. The cost of drilling wells, he said, ran from $40,000 to $60,000, particularly in the Texas and California fields.

The Appalachian fields give oil which ranges from 40 to 48 deg. Baumé; Mid-Continent fields, 27 to 40 deg.; Gulf fields, 14 to 25 deg.; California fields, 12 to 30 deg., and the Mexican fields, 10 to 20 deg.

He said that about 150,000,000 bbl. of oil is used in the United States per year for fuel, including distillates.

Some of the large consumers of oil on the Pacific Coast, such as the Southern Pacific Co. and the Santa Fe R.R., are now using Mexican instead of California oil. The marine use of California oil is heavy. In 1918 Mexico produced 63,000,000 bbl. of oil, or about 15 per cent. of the world's supply, and in 1919 the production will be approximately 80,000,000 bbl.

The first well driven in Mexico was that by Doheny in 1901. The largest Mexican well gave 1,000,000 bbl. of oil per day for five days, but much of the oil was lost because inadequate storage facilities prevented saving all of the flow. One well, opened in 1914, gave at the beginning 264,000 bbl. per day. This well is still in operation, but at a reduced rate. The wells of Mexico, according to Mr. Thomas, now produce from 10,000 to 60,000 bbl. per day. In February, 1919, there were 299 wells producing oil in Mexico, and up to this time 500 had been abandoned since 1901.

The Tampico fields give oil that runs from 10 to 14 deg. Bé. and are responsible for about 30 per cent. of Mexico's production. The Tuxpam fields give oil from 10 to 19 deg. Bé. and are responsible for about 70 per cent. of the production. The Tuxpam oils contain 10 to 15 per cent. of the light distillates, which are driven off by distillation before the product is marketed as fuel oil. The Tampico oils, which are much heavier, are not generally topped. The topped fuel is, of course, cleaner and much safer. The flash point will run about 200 deg. F., and the heating value will average about 18,400 B.t.u., giving about 149,000 B.t.u. per gal.

While the present production of Mexican oil will run from 80 to 90 million barrels per year for 1919, the United States Geological Survey estimates that the potential capacity of Mexico is about 1,000,000 bbl. per day, while the Mexican Petroleum Commission estimates the capacity at 2,000,000 bbl. per day. About 175,000 bbl. per day is now taken from Mexican wells.

The various oil companies, said Mr. Thomas, are now ready to spend $100,000,000 in the further development of the oil business in Mexico.

About one-half of the vessels of the United States Shipping Board Emergency Fleet Corporation use oil, while the navies of the world are very heavy users of it.

As bearing on the coal and oil shortage, Mr. Thomas mentioned that England's export coal trade heretofore amounted to about 70,000,000 tons per year, whereas now it is down to 30,000,000 tons per year. Of the 326,000,000 bbl. of oil produced in 1916, about 75,000,000 was used for fuel purposes.

It is Mr. Thomas' opinion, based upon the figures available to him, that the Mexican oil supply will be equal to the demand at least for some time to come. The history of the oil business up to date has shown that there is a steady increase in production, but the demand has kept ahead of this. As illustrated why this demand comes about, he said that 6,000,000 automobiles required about 100,000,000 bbl. of gasoline per year in 1918.

Surveys seem to show, he said, that there are in the ground about 6,740,000,000 bbl. of oil. The shales of Colorado and other American states contain oil to the extent of about 25 gal. per ton of shale, and the deposits are capable of producing 75,000,000,000 bbl. The cost of producing oil from the shale, he said, ran from 1½c. to 2c. per gallon. Fifty per cent. of the oil resources in the shale is equal to 50 times the production of petroleum in 1914.

Mr. Thomas here enumerated several advantages of fuel oil over coal as a boiler fuel, but these are so widely known that they are not enumerated here.

One of the advantages that he gave was the "low cost of equipment for the burning of the oil." It is to be regretted that there was not more discussion of this phase of the subject, as it is of vital concern, particularly to the large user, and is one of the two vital factors that convince one that one ought to make the change or discourage one from further considering the change.

Speaking of the storage capacity that a plant ought to have, he said that this would, of course, vary with local conditions, but it should be one week's supply at least, some plants requiring a month's supply. He deems it advisable to use two storage tanks so that one may be available for use while the other is being cleaned or subject to repair. Up to 100,000 gal. the horizontal tank, about three feet underground, is most desirable. For greater capacities the vertical steel tank above ground is preferable.

Speaking of the mechanical burner, he said that it used oil at about 200 deg. F. under high pressure at the burner. The maximum theoretical CO_2 content of anthracite coal will run about 19.2 per cent., that of bituminous coal 18 per cent., and that of fuel oil 14.5 per cent. Oil, said Mr. Thomas, is a zone proposition on account of the transportation difficulties.

At this point Dean J. K. Allen, Chief of the Research Bureau of the American Society of Heating and Ventilating Engineers, which is operated in conjunction with the United States Bureau of Mines at Pittsburgh, Penn., injected considerable humor into the meeting and also told of the work of the Research Bureau. "The essence of practice is research," said Dean Allen. He was interested in "utilitarian research, which applies not only to the engineer, but to the community."

Mr. Peabody Presents the Consumer's Point of View

The chairman then introduced E. H. Peabody, who made it plain that he could express the subject only from the consumer's point of view by giving his point of view of the consumer's point of view. In the combustion of oil, he said, the greatest problem is the reduction of excess air. "The oil supply appears not to be sufficient to meet our needs." The two questions which confront the consumer and which are of vital importance are: Can oil be obtained in necessary quantities and with necessary regularity? What will it cost compared with coal? As to labor saving, the advantages are all with oil. This is true even in the production, for it requires considerably less labor to produce a given heat value in oil than

with coal and the consumption requires far less labor. No generalities can be made to cover all plants as every plant presents a peculiar problem of its own. As to the relative cost of coal and oil, Walter M. McFarland, of the Babcock & Wilcox Co., has deduced a simple relationship in the cost of producing steam by oil and coal. In round numbers a pound of oil is equal to a pound and a half of coal, or approximately one ton of coal is equal to four and a half barrels of oil. Oil at two cents a gallon equals coal at four dollars a long ton. This ratio will hold for oil prices; the quality of coal, is of course, assumed to be fairly high, having a heating value of approximately 14,300 B.t.u. per pound.

It is not so much the burner that is of importance in an oil-burning plant as it is the furnace and the methods of admitting and controlling the air for combustion. The choice of burners, said Mr. Peabody, invariably reduces itself to the mechanical design of the burner as it permits of ease of repair, removal and replacement.

There are, so far as the speaker could determine, no advantages in any system that attempts first to gasify the oil completely before its combustion in the boiler burner. This has been tried but the developments have now ceased.

The history of oil burning in this country began in 1901 with the discovery of the Texas gusher, Spindle Top, and continued for some little time until oil became so valuable for refining that further developments in its combustion in furnaces was stopped. It had not occurred to the speaker that Doheny's Mexican well had been discovered in the same year that Spindle Top had been discovered. Speaking of the advantages of the outside over the inside mixing burner, Mr. Peabody claimed that experience had shown that there was really no advantage possessed by the inside mixer, but rather that the advantages lay with the outside mixer. This is because atomization cannot take place inside a mixing chamber, but must take place at the orifice of the burner. Schutte's mechanical burner was the first to be brought out in the United States, and the development of this burner was soon added to by Mr. Koerting. In 1907 the United States Navy Department experimented very widely with the mechanical burner, and it is, in part at least, because they confined their experiments chiefly to the mechanical burner that this type is found universally aboard ship. At any rate, said Mr. Peabody, it is to be regretted that the Liquid Fuel Board did not more widely consider steam atomization.

In modern naval practice the boilers aboard destroyers have from 11 to 16 burners per boiler. The flat spray has distinct advantages in many cases, said Mr. Peabody, and he and his associates have tried to develop a mechanical burner that would give a flat spray, but so far have not produced one that was as successful as desirable.

The Viscometer Has Not Been Standardized

Speaking of the viscometer, Mr. Peabody expressed deep regret that this had not been standardized, particularly in America. The Engler instrument is widely used on the Continent, and also in this country. As a matter of fact, said Mr. Peabody, "I do not recall what viscosity in terms of the Saybolt instrument is." He tried to secure tables giving the comparison of the standard Saybolt, Redwood and Engler viscometers, but while a few comparative figures of this kind are published, as for example in the United States Navy Oil Specifications and also in Redwood's "Treatise on Petroleum," he was told that no tables had been made for the reason that the relationship of the three scales differs with different characters of oil. This is but one of the added complications in the present practice of measuring viscosity.

In view of the fact that until recently it has been the practice of the petroleum companies to recommend that the temperature of the oil delivered to the steam-atomized sprayer be kept at about 145 deg. F., it was of interest to hear Mr. Peabody say that he has never heard of any trouble by heating oil above its flash point, within reason. Of course if there are bad leaks, these leaks will be in some degree worse than they would be if the oil were not heated so high, on account of the gas that may leak through. In line with what Mr. Peabody says, it is generally known that experience, particularly in New England, is showing that excellent results are had where the temperature of the oil at the burner is kept at about 165 deg. F.

Mr. Peabody here went into a description of several types of air registers for mechanical burners and said that nobody can tell just what will be the action of a register, inasmuch as they are indeed very capricious.

"There are no advantages in burning oil and coal at the same time," said the speaker.

It was of interest to hear him say that the mechanical atomizer has an assured field for land service. The advantage lies in the fact that the fireman has little or nothing to do with the amount of steam that may be required to burn the oil. With steam atomization, he said, there is absolutely no limit to the amount of oil a man may waste. With a coal fire one can only abuse it about so much and then the fire will go out, but with oil there is practically no limit, other than the capacity of the burner to flow oil, to which the oil may be wasted.

At this point Mr. Peabody gave some figures from the oil tests recently conducted by the United States Navy at the League Island Navy Yard, with the new type three-drum marine B. & W. water-tube boiler. In these tests astonishingly marked progress was made in the ability of the burners to burn oil at high rates of capacity. When one realizes that in 1907 from 400 to 500 lb. per burner was the limit, one gets an idea of the progress that has been made in but a few years. In one test a combined efficiency of 83 per cent. was had. 1⅓ lb. of oil per square foot of heating surface was burned, 15 lb. of water per square foot of heating surface per hour was evaporated. In the test where 83 per cent. efficiency was had, the rating was 150 per cent, 1½ lb. of oil per square foot of heating surface was burned and 22¼ lb. of water per square foot of heating surface was the evaporation rate. *Power* hopes to be able to obtain these test results from the Navy Department at an early date.

Discussion of Papers

Charles Bigelow, in answer to a question, received the reply that some gasolines were available in America from the Mexican oils.

Horace P. Liversidge, assistant chief engineer, Philadelphia Electric Co., was of the opinion that small plants having a load factor of 35 per cent. presented an entirely different problem from the cost standpoint from plants having a higher load factor, say 50 to 60 per cent. and above; he believes that the plant with the lower load factor, say 60 per cent. down, might find it economical to use oil, but that the plant with a higher load factor would not. He said that the supply of coal is quite stabilized as compared with the supply of oil. There are two classes of installation—one where coal is already in use when a change to oil is contemplated, and the other a new plant where the initial installation may be for coal or oil. Each class presents a different problem in the matter of cost, particularly investment cost, and their influence upon the question of whether it would be worth while to change from coal to oil. In answering, Mr. Peabody said that he did not regard the question of load factor as a serious one, but thought that in either direction above or below 60 per cent. load factor oil should show an advantage over coal from a combustion-cost standpoint. The matter of investment necessary for the changeover was, of course, an important one.

Mr. German, of Waterbury, Conn., in answer to an inquiry, was told that a steam atomizer uses about 1½ to 2 per cent. of the steam generated by the boiler for use in atomizing and that the mechanical burner requires a small amount in addition.

Mr. Lewis, of the Buffalo Forge Co., in answer to an inquiry, was told that the oil-burner designers do not figure on injection action to induce air for combustion.

W. J. Pollack, of the Badenhausen Co., asked if stokers should be removed or left in when the change is made from coal to oil. Mr. Peabody was of the opinion that the stokers should be removed except that he called attention to the fact that there were settings that had the oil burners located at one end of the boiler and the stoker installation at the other, thus requiring no withdrawal of the stokers in the event of using the oil equipment.

Mr. Windell called attention to the atomization of oil by centrifugal force by means of a cuff, or disk rotated by a

motor; this type of burner one will recognize immediately as the Fess, particularly adapted to small installations. Mr. Peabody believes there is a large field for this kind of burner.

C. H. Bromley, associate editor of *Power*, called attention to the lack of available data on the cost of concrete fuel-oil storage tanks and of the actual cost of changing over from coal to oil as compared with the estimated cost. Experience shows, he said, that the actual costs are considerably in excess of the estimated costs. Many at the meeting wanted cost data, but were up to date unable to obtain any that they could talk about. Mr. Bromley asked if Mr. McFarland's figures as to relative costs of performance with coal and oil, namely two-cent oil being equivalent to four-dollar coal, considered the fact that oil lends itself far more readily to complete and perfect combustion than does coal. It would not be fair to oil, he said, to base any comparative figures as to performance to be expected solely upon the relative heat values of the two fuels. In answer, Mr. Peabody said that Mr. McFarland had taken into consideration in this rough "measuring stick," as he likes to call it, the superiority of oil over coal in actual combustion.

Mr. Bromley said that experience had shown that a greater combustion volume is needed for oil, particularly at high combustion rates, than is required with bituminous coals if not of a too long flaming nature. He asked what Mr. Peabody considered should be the relation between coal and oil as referred to combustion rates and combustion volume. Mr. Peabody said that the less the volume of combustion space provided per burner, the less the ultimate capacity per burner in pounds of oil burned under fixed conditions of draft.

Excerpts from Elevator Regulations

By EDWARD A. SMITH

Mechanical Engineer, Otis Elevator Co., New York, N. Y.

EXCERPTS from the elevator regulations of the building code of Chicago, Ill., as amended June 25, 1917. For power-driven passenger, freight and sidewalk elevators. Parts of equipment not referred to in the excerpts have no regulations.

Load: Passenger, Freight and Sidewalk—No regulation. Hospitals—Three stories or over must have platform having inside dimensions, 5 x 7 ft. minimum.

Run-by at Top: Passenger and Freight—Four feet between crosshead and underside of grating.

Pit: Passenger, Freight and Sidewalk—Two feet between bottom of car and bottom of pit; car at lowest landing.

Safeties and Governor: Passenger and Freight—Existing and future installations must have safety device and speed governor as required by commissioner of buildings. No governor required on freight elevator used in tunnels for freight service only. No safeties required on building hoists for material only.

Car Enclosure and Platform: Passenger—Enclosure on sides and top. No gate required. Car to be lighted. No freight compartment permitted. Freight—Enclosure or guard 6 ft. high; solid over counterweight. No top or gate required. Car to be lighted.

Control: Passenger, Freight and Sidewalk—Switch, hand-rope, push-button, wheel or lever permitted but not specified.

Ropes: Passenger and Freight—Two ropes required to car and each counterweight. One full turn on drum when car is at limit of travel. Machine-counterweight ropes which pass through car counterweight to be covered to prevent chafing. Sidewalk—Ropes or chains permitted.

Grating: Passenger and Freight—Grating of steel or heavy wire mesh to sustain 500 lb. Under sheaves or machine at top of shaft.

Counterweights: Passenger and Freight—Parts strongly bolted together.

Stop Motions and Shaft Limits: Passenger and Freight—Drum machines to have stop-motion device on machine, not operated by link belt or sprocket chains. Shaft limits for traction machines. No link belt or sprocket chain permitted between controller and operating device. Sidewalk—Machine limits or stop balls on rope or chain.

Emergency Switches: Passenger—Emergency switch in car for switch-controlled electric elevators.

Brakes: Passenger—Electric brake on switch-controlled elevator.

Hatchway Enclosures: Passenger—Future nonfireproof building shafts to be enclosed in brick, tile or other material approved by commissioner, to extend from foundation to roof. Fireproof shaft not required if building is equipped with complete sprinkler system. Existing and future shafts that extend to lowest floor must have brick, tile or other fireproof enclosure with fireproof doors. If shaft does not extend to basement, must have fireproof pits with openings only for ropes and machinery. If hatch is not enclosed in fireproof material, shaft must have enclosure of wire guard 6 ft. high. Full height over counterweight with wire guard or other fireproof material. Underside of all sills or projections in hatchway to be beveled with smooth steel 60 deg. with horizontal. Penthouses in buildings more than 50 ft. high must be of fireproof material. Roofs may be of mill-type construction or slow-burning material. Hospitals three stories or over to have fireproof shaft. Future shafts in hotels, clubs, offices, lodging houses (twenty or more persons) to be fireproof with fireproof doors. Freight—Same as passenger except existing freight elevators need not have enclosing walls but must have trap doors, with fusible links, which will close automatically when temperature exceeds 140 deg. F. provided building is equipped with passenger elevators, fire-escapes and stairs; otherwise, elevators must have fireproof enclosures.

Hatchway Doors: Passenger and Freight—Future and existing fireproof doors which open from outside only with a key or other device approved by commissioner, must be furnished with fireproof shafts.

Trapdoors: Passenger—Not permitted. Freight—On existing shafts not required to be enclosed (see shafts) must be self-closing with fusible links which operate at a temperature of 140 deg. F.

Dumbwaiters: In nonfireproof building hereafter erected, shafts to be enclosed in brick, tile, reinforced concrete or cement plaster not less than 2 in. thick or metal studs and lath. No other regulation.

Filing: Before starting work permit must be obtained from commissioner of buildings, specifying number and kind of elevators to be erected or nature of alterations, giving location of building; plans and specifications to be filed showing construction and type of elevator and location. Commissioner will issue permit; fee of $2 for each elevator or alteration. Permit required for installing iron doors or wirework enclosures, $2 for each elevator.

Operator: Operators for passenger elevators must close all doors before starting car and must not open doors before elevator is stopped. Fine for violation, $25 to $100.

Hydraulic Tanks, Valves and Cylinders: No regulations except tanks on roofs over 400 gallons must rest on solid brick or stone masonry or girders on masonry or iron or steel construction. Plans to be approved by commissioner and permit issued; fee $5.

Installations Prohibited: Hand-power to power-driven without first making application to commissioner. Also to connect electric motor or other appliance to hand-power elevator without a permit.

Repairs and Alterations: To conform to rules for new installations.

Tests: New elevators to be inspected and safeties tested and certificate issued and posted in cars before same are put in operation. Existing elevators to be inspected every six months; fee, $2.

Factors of Safety for Construction: Maximum fiber stress that steel is to be subjected to, 16,000 lb.; cast steel, 16,000 lb.; and wrought iron, 12,000 pounds.

Industrial Economics

Phases of the above subject were up for discussion at a joint meeting of the Chicago sections of the American Institute of Electrical Engineers, American Society of Mechanical Engineers and the Illuminating Engineering Society, and the electrical section of the Western Society of Engineers, held in the rooms of the society last named on Nov. 24. Harold Almert was chairman of the committee on arrangements and presided at the meeting.

Edwin D. Tillson, testing engineer for the Commonwealth Edison Co., spoke on the topic "Reaction of Labor to Intensive Lighting" showing in the course of his paper the effect of more intensive lighting on production. The Illuminating Engineering Society for several years had been conducting a campaign to bring about a revolution in factory lighting, not only in the intensity of light used, but in the location of units and in distribution. By means of lantern slides the speaker summarized the numerous business reasons for intensive lighting, and gave results of tests to show the increase of production by good illumination. The old standard of 4 foot-candles, was not sufficient. The Edison Company was advising 12 foot-candles, and there were numerous factories that had used higher intensities with good results. The illumination on various machines was pictured with lighting of 4 and 12 foot-candles intensity, and the effect were of single, double and triple shadows were made evident. To visualize the difference in lighting intensity a factory model was used to advantage, and an instructive comparison made between drop cord lighting and intensities of 4 and 12 foot-candles. In each case the location of the machine was varied, and comment made on the intensity of light on the various working parts.

In the speaker's opinion intensive lighting offered a great opportunity for conservation. The increase in production much more than offset the cost of current. As one of the factors influencing production it should be given serious attention by the engineer, and his active support would be appreciated by the Illuminating Engineering Society which had spent years in advancing the cause.

George H. Jones, power engineer of the Commonwealth Edison Co., showed how electrical power from central stations was an important factor in affecting economies and increasing production. With electric drive the power may be applied in the most direct manner, eliminating shafting, belt or rope drive and the accompanying friction. In the generation and distribution of electrical energy; not only coal, but capital and material as well were conserved by the economy of the central station. The large and efficient machines now used are much more economical than the small units in private plants, and due to the better load factor of the central station there is greater use of capital invested. In the central station itself, there has been great improvement in economy. The old figure of 7 lb. of coal per kilowatt-hour had been gradually reduced to 2.2 lb. per kilowatt-hour, the steam rate now credited to the large turbine units. The latter figure was compared to similar data from isolated plants both condensing and non-condensing. Coal consumption running as high as 12 lb. per kilowatt-hour for a condensing plant, and still higher for a non-condensing plant, was cited by Mr. Jones, the plants apparently being especially selected to make the case as strong as possible for the central station.

Reference was made to the saving of 13,000 tons of coal by 10 relatively small plants in Chicago, which had adopted the plan of taking Edison current during the summer, and operating their own plants throughout the heating season. The speaker remarked on the growth of the central station and the reduction in rates for service, the price being even a trifle lower than in 1914, although every other commodity had gone upward. Larger units, more efficient production, and a better and more diversified load factor had made this possible.

Harold Almert talked breifly on the personal efficiency of the employee. Due to the unprecedented return of our foreign born to their respective countries, and the slowing up of immigration, the man power of the country had been reduced considerably, so that it was more important than ever to utilize labor to the best advantage. How to improve the productivity of labor was a leading question. The mental attitude had changed remarkably since the war. There was no longer the desire to serve, nor the desire for efficiency for its own sake. The employer was held at arms' length, while maximum wages were demanded for a minimum of work. To compete for trade in foreign countries, commodity prices must come down, and to this end increased production was essential.

To bring this about there must be improvement of methods and machinery, and labor must turn about face and do a day's work. Statistics showed that production per man ranged from one-quarter to one-half of what it was in 1914. These facts must be brought home to the conservative element, so that they may again assume leadership. With the parasites and radicals who now rule labor, improvement could not be expected. Psychology must be applied to the problem of increasing organization efficiency. It would be necessary to make a more accurate study of human nature, select the right man for the respective position, show the workman that it is quite feasible to do from two to four times the present quota, and on the other hand provide working conditions that will be conducive to efficiency.

Economy of Colliery Boiler Plants

By D. Bronlie

The following is from a reprint from *Engineering* (London) July 25, and Aug. 1, 1919: I propose to give in this article the exact working details of 100 typical colliery steam boiler plants in Great Britain in order to undertake efficiently the whole question of national coal economy. I hope to show that the average mean working efficiency in colliery steam boiler plants is only 55.5 per cent and that by carrying out a reorganization of these plants on modern scientific lines it is usually possible to run them on 70 per cent. This will represent an average saving of about 21 per cent in the national coal consumption of, say, 18,500,000 tons per annum, corresponding to a saving of no less than 3,900,000 tons per annum. This saving can be obtained by burning the existing coal more efficiently, but in addition at least another 15 per cent equal to, say, 2,775,000 tons, can be saved by burning refuse coal, so that the total saving would be 36 per cent, or 6,600,000 tons per annum.

The figures given in this reprint are the result of tests of one week's duration.

The 100 plants have a total of 570 boilers comprising 500 Lancashire, 2 Cornish, 38 egg-ended and 31 modern tubular boilers. The typical boiler today is undoubtedly the Lancashire of an average of about 30 ft. x 8 ft. 6 in. The extremely low efficiency of the old egg-ended boiler will be noted, the average being less than 35 per cent as against, say, 55 per cent for the Lancashire. It is interesting to analyze the results obtained from the quality of coal used in the 100 plants. In the first place the two mathematical average figures for the 100 colliery boiler plants are 10,500 B.t.u. and 15.5 per cent ash, as compared with the figures of 259 typical boiler plants with 11,822 B.t.u. and 11.5 per cent ash.

The average price for the whole of the coal burned in colliery plants irrespective of quality would be about 50s. per ton. That is to say the coal bill of the whole colliery industry is about £18,500,000 per annum.

The almost universal practice of colliery plants is hand firing, and in the writer's opinion this is the correct method. In the 100 plants only five are mechanically fired and the average results were, if anything, slightly inferior to hand firing, quite apart from possible upkeep of the stokers. The figures for the 250 plants show 24 per cent mechanical firing.

In all the 100 plants, in not one case was any apparatus installed for determining regularly the feed water evaporated. In most cases 25 to 50 per cent of boilers in operation in collieries could be shut down and the same amount of steam generated with much better efficiency from the remaining boilers.

The average combined efficiency for the 100 plants is 55.52 per cent.

The plants are operated under very inferior conditions as regards output of boiler; 25 to 50 per cent of the boilers in collieries can be shut down. Practically no proper use is made of economizers and 15 per cent of the coal bill is wasted because of the lack of these.

The Lubrication of Ball Bearings

By H. R. TROTTER

AT the present time there is, unfortunately, no instrument that will accurately indicate the true lubricating value of an oil or grease, and until such an instrument is devised, the selection of a lubricant must be more or less a matter of guesswork. A viscosimeter gives a comparative reading of the inertia of a liquid, but it does not indicate the value of a lubricant under working conditions. Furthermore, all authorities are not agreed on the desirable qualities of a lubricant. Many claim that a high surface tension is a requisite, and others lay great stress on adhesive qualities. All are agreed, however, that a lubricant should have the minimum

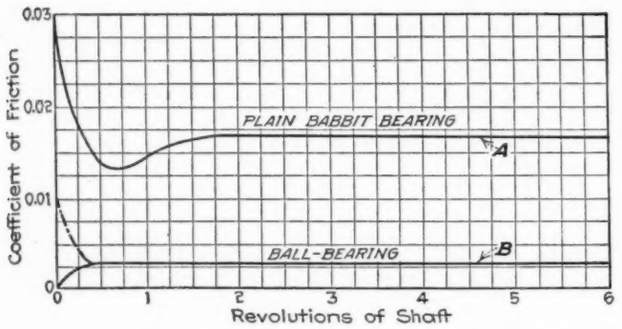


FIG. 1. FRICTION-COEFFICIENT CURVES OF A PLAIN AND A BALL-BEARING

of internal friction. Generally speaking, a lubricant for the plain-sleeve type of bearing requires a certain amount of adhesive quality to enable it to adhere to both the revolving and the stationary surfaces. It should have sufficient body to withstand the pressures. The lubricant film will, therefore, consist of three layers, which in operation approximate the features of a ball bearing in that one element is stationary, one rotating and one an intermediate layer consisting of globules, similar to the ball in a ball bearing. From this description the importance of body in a lubricant will be realized, and as the best and toughest material is required in the balls of a ball bearing, so is body required in the intermediate layer of a lubricant.

The two cardinal points of successful sleeve-bearing operation are: (1) A design of such type as will permit of the formation and preservation of an oil film; (2) selection of a lubricant that will provide a film of maximum strength with a minimum of internal friction.

With a ball bearing, however, the problem is not so easily understood, but the important points to be remembered are: (1) The coefficient of friction is practically constant throughout wide ranges of loads and speeds; (2) metal-to-metal contact (an oil film only possible at very high speeds when slippage may take place); (3) the coefficient of friction is lower in an unlubricated ball bearing (at light loads and moderate speeds).

The first point is, of course, generally known, but the conclusion to be derived from this point has not been stated before to the author's knowledge; namely, the impossibility of an oil film between balls and races.

In Fig. 1 curve *A* shows the change of friction coefficient of a plain bearing under constant load and varying speed. The curve is self-explanatory and shows that a satisfactory oil film is not formed till a certain speed is reached. In the same figure curve *B* gives the friction coefficients of a well-made ball bearing and shows that the friction loss of a ball bearing is practically constant throughout wide ranges of speed. If an oil film were formed between balls and races, curve *B* would possess the same general characteristics as curve *A*.

The difference between the friction coefficient of a lubricated and an unlubricated ball bearing is shown in Fig. 2. This property of a ball bearing is not generally known and should not be used as an argument in favor of operating ball bearings without lubrication. From the foregoing statements it should be evident that plain bearings and ball bearings possess such radically different characteristics that a true comparison is impossible. It naturally follows, therefore, that practically all the accumulated experience of the lubricating engineer is of little value when analyzing ball-bearing operation.

The use of a lubricant with ball bearings is necessary to protect the highly polished surfaces of the balls and raceways, and to minimize the slight friction between the balls and ball retainer. The small amount of friction between balls and retainer can also be minimized by careful design. The principal requirement of a ball-bearing lubricant is chemical neutrality. The lubricant used must not contain over 0.10 per cent. acid or alkali. There are on the market many commercial lubricants that come within this limit, but very few are acceptable because of their tendency to develop acid with age or when operating at high temperatures.

Most of the high-grade oils can be used with safety, but many of the lubricating greases, while suitable for general purposes, are a positive menace to successful ball-bearing operation, not because of poor material used in the manufacture of greases, but because of the lack of scientific mixing methods. The manufacturer is in no way to blame for this condition, because he is making grease for general commercial use and not for ball bearings. There are now on the market a few greases manufactured especially for ball bearings, but with one exception all those tested by the author have proved worthless and clearly indicate the maker's ignorance of the requirements.

Experience shows that the most satisfactory lubricant for ball bearings is a highly refined mineral oil having the proper viscosity and cold test for the installation. Greases should be used only where operating conditions require viscosities greater than can be obtained with a mineral oil.

Whenever a ball bearing is operated at high speeds, it is not advisable to run it submerged in a lubricant, and provision should be made to supply the oil from a pressure system. If such a system is not available, good results may be obtained by a large sight-feed oil cup. A few drops of oil per minute is all that is required.

At moderate speeds a heavy oil will generally give better results than a light oil. The substitution of a heavy oil for a

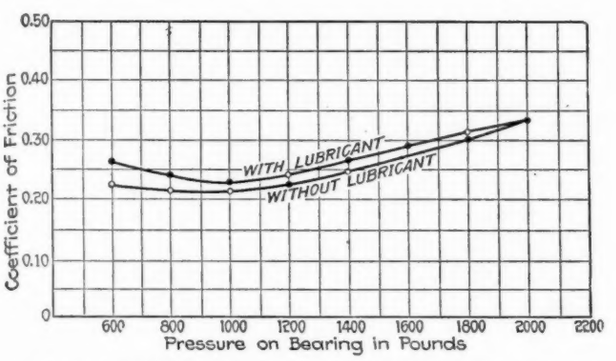


FIG. 2. FRICTION-COEFFICIENT CURVES OF A BALL-BEARING WITH AND WITHOUT LUBRICANT

light oil will generally result in a decreased operating temperature. This peculiarity may be explained by the fact that when the bearing is running at the actual operating speed, less opposition is offered to the rotation of the balls by the oil because of the inertia of the oil. In addition there is less churning and frothing with its resultant air pockets. Air pockets in a lubricant act as insulators and prevent the transmission of the heat generated to the outer casing where it can readily be dissipated.

All mineral oils used on ball bearings should be highly refined, filtered and contain a minimum amount of acid, alkali

*Abstract from a paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Dec. 2 to 5, 1919

or sulphur compounds, and in order to insure the use of such oils the following specifications are suggested:

Free acid (calc. as oleic acid), maximum, 0.10 per cent.
Free alkali, absent.
Ash, trace.
Heat test (15 minutes at flash point), slight darkening, but no sediment.
Flash point (Cleveland open cup), minimum, 300 deg. F.
Fire test, minimum, 350 deg. F.
Viscosity at 100 deg. F. Saybolt Universal: Light oil, 100 to 200 seconds; medium oil, 200 to 300 seconds; heavy oil, 300 to 500 seconds; extra-heavy oil, more than 500 seconds.

Most of the high-grade mineral oils conform quite closely to these specifications. In connection with lubricating greases, however, the problem is more difficult. Many of the greases now on the market are entirely satisfactory for general purposes, but lack certain characteristics which experience shows to be highly important for successful ball-bearing lubrication.

A large number of greases contain lime-soap as thickeners, a few are of the soda-soap type, while others are a combination of both. The lime greases are valuable in that they can be used without harmful results where moisture is present. Their consistency, however, is more easily changed by heat than greases of the soda type. Ball bearing manufacturers are quite agreed that the limit of free acid in a grease should not exceed 0.10 per cent. calculated as oleic acid, and plenty of greases that meet this requirement are available.

It is essential that the grease be comparatively free from unsaponifiable fatty oil, or as expressed in the analyses, "neutral saponifiable oil." This specification is imposed because the unsaponified fatty oil has a tendency to become rancid or develop an acidity with age in service, particularly when operating at high temperatures. We have established a limit of 1 per cent., and this can be met in most of the compounds that are suitable in other respects.

One feature of grease lubrication that cannot be too highly emphasized is the importance of using a high-grade mineral oil. A grease may be perfect in every other respect, yet if a poor grade of mineral oil is used, the life of the bearing will be shortened.

Some manufacturers take advantage of the fact that a grease made with kerosene looks much the same as one containing high-grade oil and cheapen their product by using inferior light oils. It is desirable that a highly refined oil showing about 200 sec. viscosity Saybolt Universal at 100 deg. F. be used in the ordinary grease formula. In view of the high polish necessary on ball bearings, the elimination of abrasives such as sand particles, etc., is manifestly important.

At the present time there is no generally accepted method for determining the consistency or melting point of a grease.

The highest-grade ball-bearing greases are put through a milling process after compounding. This treatment insures very intimate mixing of all constituents and pulverizes any chance impurity to an impalpable powder. It is strongly recommended that all greases for ball bearings be so treated.

Graphite, despite its unctuous qualities, cannot be regarded as a true lubricant. It can, however, be used with success in plain bearings, as it fills in the interstices in the bearing surfaces and allows the true lubricant to operate efficiently. A modern well-made ball bearing with mirror-like finish has, however, practically no interstices in the balls and raceways. A perfectly finished ball shows no scratches when magnified 100 diameters, and furthermore, were there irregularities present, graphite would not eliminate them, as there is considerable difference between the sliding action of a plain bearing and the rolling action of a ball bearing.

Graphite, moreover, has a tendency to pack in the ball retainers and raceways, and a bearing that has been lubricated with graphite grease generally has a distinct wavy appearance in the ball paths. A recent brief test of a grease containing collodial graphite revealed the fact that while the graphite did not pack in the raceways, and the wavy ball paths were absent, the complete raceway presented a burnished appearance quite different from that obtained by the use of ordinary greases. The graphite packed hard in the ball retainer and could not be removed by dipping in gasoline. The use of graphite in ball bearings cannot, therefore, be regarded as beneficial, and its application is purely a question of economics.

Bearing for High-Speed Gears

According to *The Engineer*, London, K. Baumann and the British Westinghouse Electric and Manufacturing Co., London, have patented a bearing for high-speed gears that is supported in position by films of oil, which are maintained by forcing the oil through one or more relatively small clearance spaces provided between the bearing and its support. In this way any vibration that may be set up is absorbed by the film of oil, which provides a cushioning effect; also the position of one bearing with respect to another may be adjusted by forcing a greater quantity of oil through the clearance space or spaces between one bearing and its support than through the clearance space or spaces of the other bearing, and this adjustment may be made while the apparatus is in motion. Accurate alignment of the coöperating teeth may be secured automatically by supplying the oil films to the different bearings of the gear from a single source.

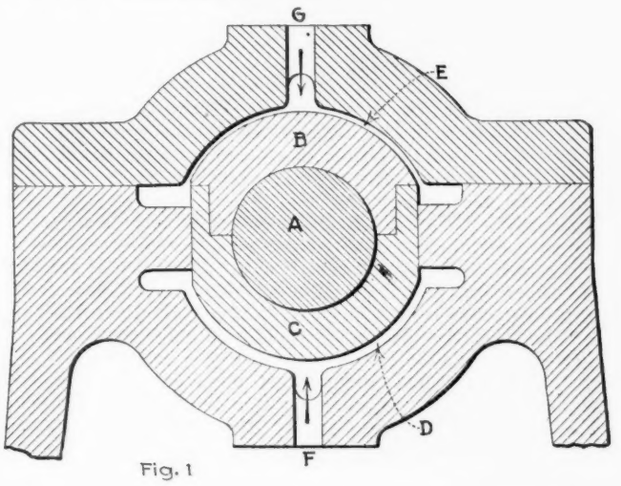


Fig. 1

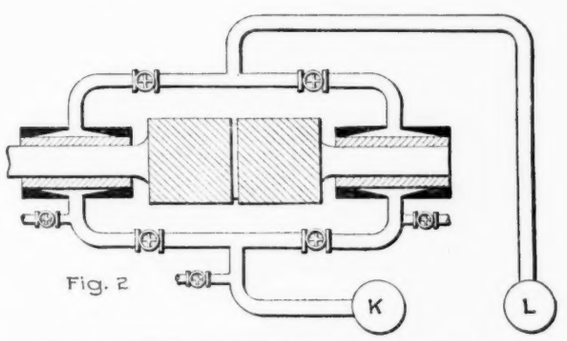


Fig. 2

FIG. 1. DESIGN OF HIGH-SPEED BEARING
FIG. 2. PINION SHAFT SUPPORTED BY TWO BEARINGS

Referring to Fig. 1, a shaft journal *A* is supported between upper and lower bearings *B C*. Between the lower bearing and its housing and between the upper bearing and the cap clearance spaces *D E* are provided, and passages *F G* lead respectively into these two clearance spaces, through which oil under pressure is forced, the bearing being maintained in position by the oil films thus formed in the clearance spaces. The bearing is provided with vertical guide surfaces, which coöperate with guide surfaces in the housing, and drains are provided on each side of the bearing for leading away the oil from the lower and upper clearance spaces respectively. With this construction the bearing may be raised by increasing the quantity of oil supplied to the lower clearance space *D*, as compared with that supplied to the upper clearance space *E*.

Fig. 2 shows a pinion, the shaft of which is supported in two bearings, and each bearing may be of the form illustrated in Fig. 1. Oil is supplied to the lower clearance spaces by an oil pump *K* and to the upper clearance spaces from a pump *L*. Throttle valves are provided in each branch pipe, so that the amount of oil supplied to the several clearance spaces and,

consequently, the position of either bearing may be independently adjusted as required. In addition to, or in substitution for, the throttle valve, a by-pass or relief valves may be provided for adjusting the quantity of oil supplied to both the lower clearance spaces at the same time or to either of them independently. With this arrangement very fine adjustment of the position of each bearing can be obtained by manipulating the valves, all of which may be located in accessible positions outside of the gear casing. Instead of supplying the oil to the clearance spaces from a pump, a supply of oil may be tapped from the oil film of the journal at a point where it is under pressure, thus utilizing the well-known property of journal lubrication for the generation of the necessary pressure. Where an external pump is employed, the oil may be used for lubricating the journal after passing through the clearance space or spaces.

Consolidation of Power Plants

In reference to the extensions of the Kentucky & West Virginia Power Co., Lothair, Ky., announcement has been made as follows by Francis R. Weller, consulting engineer, Washington, D. C.:

The Kentucky & West Virginia Power Co. acquired the Logan Light & Power Co., Logan, W. Va., the Tug River Power Co., Sprigg, W. Va., and the Kentucky River Power Co., Lothair, Ky. The company supplies power to various mines in the southern part of West Virginia and eastern Kentucky. These are largely non-union fields and are developing rapidly, so a very comprehensive program for enlargement of the power plants in the extension of transmission lines is now starting. The power plant at Logan, having 15,000 kw. capacity, will be enlarged by installing two 15,000-kw. turbines. A new boiler house will be constructed with six 1000-hp. water tube boilers, stokers and economizers.

At the Logan plant an 88,000-volt line will connect the Logan and Lothair plants, a distance of over 100 miles. Construction has been started on this line and it will be built by the company's construction forces. At Sprigg a 3000-kw. turbine and condenser is now being installed and it is intended to increase the capacity further by two 10,000-kw. turbine and surface condensers, also by building another boiler house.

At Lothair the boiler room will be extended, and two 833-hp. boilers with underfeed stokers will be installed, and a 3000-kw. turbine and surface condenser is being installed. The 44,000-volt distributing lines in the Logan district will be extended to serve new mining interests. The 33,000-volt transmission lines in the Sprigg and Lothair districts will likewise be extended.

The company purposes installing a 10,000-kv.-a. step-down substation in Pikeville, Ky., on the Big Sandy River, which will be on an 88,000-volt transmission line and a 44,000-volt distributing line extended from the Pikeville substation to supply all the mines in the Big Sandy Valley. Nearly all the contracts for the Logan work have been awarded with the exception of one for the power-plant building, including structural steelwork.

R. E. Breed, of New York, is president; George N. Tidd, New York, vice-president; H. T. Hartman, Philadelphia, vice-president and general manager; A. J. Darrow, manager, Logan division; M. C. Funk, manager, Sprigg division; W. F. Fickle, manager, Lothair division.

Committee on Water Power Development

President R. H. Ballard announces that the Committee on Water Power Development under the chairmanship of Franklin T. Griffith, president of the Portland Railway, Light and Power Co., Portland, Ore., will include the following personnel:

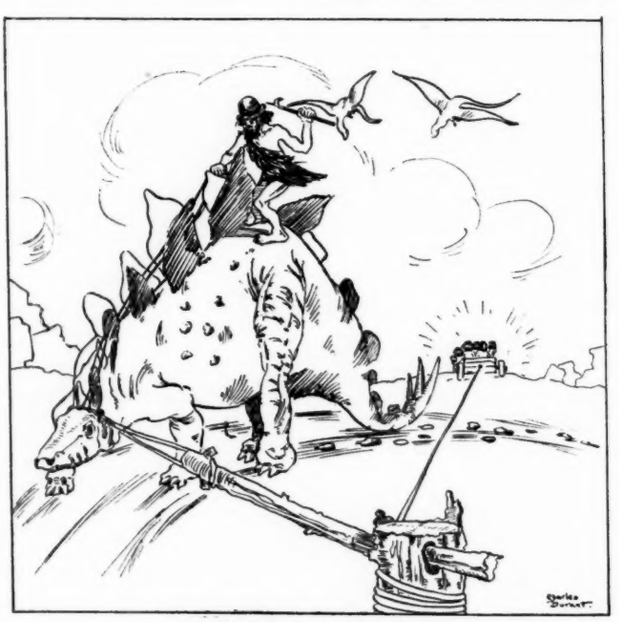
William A. Brackenridge, president, Southern California Edison Co., Los Angeles; John A. Britton, vice-president and general manager, Pacific Gas and Electric Co., San Francisco; H. T. Edger, president Mississippi River Power Co., Keokuk, Iowa; G. C. Egbert, consulting engineer, Niagara Falls Power Co., Niagara, N. Y.; Mortimer Fleischhacker, president, Great Western Power Co., San Francisco; H. I. Harriman, president, New England Power Co., Boston, Mass.; D. I. Huntington, president, Washington Water Power Co., Spokane, Wash.; H. F. Jackson, president, Sierra & San Francisco Power Co., San Francisco; Frank M. Kerr, vice-president and general manager, Montana Power Co., Butte, Mont.; W. S. Lee, chief engineer, Southern Power Co., Charlotte, N. C.; A. W. Leonard, president, Puget Sound Traction, Light and Power Co., Seattle, Wash.; J. D. McKee, vice-president, California-Oregon Power Co., San Francisco; G. W. Talbot, president, Pacific Power and Light Co., Portland, Ore.; A. B. West, vice-president and general manager, Southern Sierra Power Co., Riverside, Cal.; A. G. Wishon, vice-president and general manager, San Joaquin Light and Power Co., Fresno, California.

A complete investigation of the water-power resources of the country, both developed and undeveloped, will be undertaken by this committee. The great aid to national industrial and agricultural development that commercial and economic use of the nation's natural resources in water supply will be fully set forth for the benefit of the industry at large, bankers and investors. A study will be made respecting the practical application of pending national legislation on the subject and of the economic advantages to be obtained through a more general interconnection of water power systems.

New Power Plant Being Built on the San Joaquin River

To meet the increasing demands for power in the San Joaquin Valley, the San Joaquin Light and Power Co. is building a new plant on what is known as the Kerckhoff power site, near Auberry, Calif. This plant will use the entire flow of the San Joaquin River. A dam 150 ft. high is being built across the river about four miles about Auberry, and from here the water will be diverted into a 17-ft. tunnel 17,000 ft. long to the forebay, from where it will pass through three 8-ft. steel penstocks to the hydraulic turbines in the power plant.

The turbines are of the vertical Francis single-runner type, and each is capable of developing 15,000 hp., and drives an alternator of 14,200-kv.-a. capacity at 80 per cent. power factor. The revolving element of each machine will be supported on Kingsbury thrust bearings. Excitation of the alternators will be obtained from two 300-kw. exciters driven by 500-hp. Francis-type turbines. The power developed in the plant will be stepped up to 110,000 volts through three banks of transformers, each bank consisting of three 5000-kv.-a. units, or a total of 15,000 kv.-a. to the bank. It is estimated that the development of this project will cost $5,000,000.



THE FIRST ENGINEER

Rapid Adoption of Automatic Substations*

The first automatic substation control was put into operation on Christmas Eve, 1914, in the Union substation of the Elgin & Belvidere Electric Ry., and in the following August the two remaining substations of this road were equipped. The success of the venture immediately attracted the attention of railway engineers so that several automatic-control equipments and complete substations were purchased and installed in 1916. It is of interest to note that the second railway company to install an automatic railway substation decided to operate a semi-outdoor station, provision being made for housing only a 500-kw. rotary converter, the switchboard and the drum controller. At this time two other systems decided to install a total of 12 automatic equipments. One of these early installations was the first portable automatic substation. In 1917 the first installation involving the operation of two synchronous converters in series was made, and in 1918 two synchronous converters were first automatically operated in parallel. Two more portable automatic substations were put into service in this year. Four and one-half years after the first experiment was made, there were 35 full-automatic and two semiautomatic, or remote-controlled, substations in actual operation and an additional 31 automatic and four semiautomatic equipments stood on order with manufacturers. These 72 equipments control several types of synchronous converters and motor-generator sets of capacities varying from 200 to 2000 kilowatts.

On May 1 a number of control equipments sufficient to control 37,500 kw. of rated machine capacity had been purchased. Thus far the tendency has been to apply automatic control more generally to machines having rated capacities of 500 kw. and under, the total number of machines coming within this range being 58. This number includes twenty 300-kw. and twenty-eight 500-kw. units. A good inroad is, however, being made on machines of larger capacity, as one 1000-kw. synchronous converter is now operating automatically and six 1000-kw. synchronous converters, one 1000-kw. motor-generator set, two 1500-kw. synchronous converters, and one 2000-kw. motor-generator sets are on order and will probably be put in service before the close of 1919.

While 44 stations are to receive 25-cycle energy, a total of 18 stations are to receive 60-cycle energy and 8 stations will operate at odd frequencies including 30, 35, 40 and 50 cycles. The high-tension line voltage varies from 2200 to 66,000. The trolley voltage supplied is generally standard at 600 volts direct current, excepting one 1200-volt direct-current system and one 1500-volt direct-current system.

While the largest synchronous converter yet to be automatically controlled is a 1500-kw. machine and the largest motor-generator set a 2000-kw. machine, there is at the present time in operation a 3000-kv.-a. synchronous condenser. The first automatically controlled waterwheel generating station, which contains three 500-kw. generators arranged to operate in parallel either under the influence of full-automatic control at the generating plant or controlled if desired by an operator in the main steam-generating station at a distant point, was put in operation in 1918. The success of this installation without question makes possible the development of a considerable number of small water powers that otherwise could not be developed because of the cost of operating labor.

Several companies have chosen automatic equipment in consideration of the saving possible from the elimination of light load losses, as well as from a consideration of saving in labor. The largest figures received gave an estimated saving of $400 per annum on a 300-kw. station and $700 on a 500-kw. station. One company installed a 250-kw. automatic station to replace a floating battery between two substations ten miles apart, in preference to spending $5000 for necessary repairs to the battery. When some of the automatic substations were built in new locations, however, it was in several cases possible to remove feeder copper which possessed a value sufficient to offset in part the cost of construction of the substation building with its equipment. In an exceptional case the cost of construction of a two-unit substation containing two 300-kw. synchronous converters was more than offset by the value of the feeder copper that was removed from the distribution system, and a more satisfactory line voltage was maintained on the line as a whole. The most notable saving in copper was made in Des Moines, where, through the installation of a system of automatic substations, an amount of feeder copper was taken down which, at 20c per pound, was worth $90,200, and at the same time a substation and distribution system were obtained which cost according to estimate $141,700 less than an equivalent system to give the same voltage regulation would have cost had additional manually operated synchronous converters been placed in the central power station and additional feeder copper put up on the outside lines. As an example of another exceptional case, it has been estimated that one important interurban line in central New York State, "because of its surplus feeder capacity can, by adopting automatic substations and removing part of this copper, make an annual saving of $24,000 with approximately zero investment." These examples are unusual, but are given to illustrate the possibilities that are offered in not a small number of cases.

It was brought out in the discussion on this report that at the present time the economic limit in automatic substation capacity is about 6000 kw.; above 6000 kw. it is more economical to install manually operated equipment.

*Abstract from the report of the Committee on Power Generation presented at the convention of the American Electric Railway Engineering Association, at Atlantic City, N. J., October, 1919.

Practical Aspects of Employees' Representation*

By E. B. Tolsted

There has been so much misused power on both sides of industrial disputes that some method must be developed to eliminate it in the interest of the nation as a whole. To careful thinkers the solution lies definitely along the line of a clear understanding by each side, of its own attitude, of the problems of the other and of their joint relation to society. Just how this understanding is to be brought about is the big problem before the industrial world today.

The most prominent plan at present for the solution of this problem is the employees' representation, or so called "shop committee" plan. Many employers consider this plan better than the labor union, and under proper circumstances it can and does work in connection with the unions.

There are at present about 150 employees' plans in operation in the United States, and this paper is the result of a personal investigation of about fifty of them. Among these there is a wide variety of scope and power. An individual case may provide simply an orderly method for presenting grievances, it may provide machinery for collective bargaining with reference to wages, hours and working conditions, or it may enter into any or all of the relations between the employer and the employees. Structurally, it may be very simple or very elaborate. Its power may be simply advisory, or the employees' representatives may be given final authority in one or many of the questions that may come up. The fact should be emphasized that in no plan investigated had the control gone as far as what is known as "Industrial Democracy."

Results Accomplished by Works Committees

Several years ago one employer, who was working under a representation plan, stated after ten years of experience that about 90 per cent. of the employees' complaints were justified. In the large majority of the cases brought up the decision was immaterial to the employer. Under the older system many of these complaints smoldered unseen until they caused real trouble, when the employer would have gladly adjusted them if proper means had existed to bring them to his attention.

Many grievances are the result of petty tyrannies on the part of foremen or other subordinate authorities. When there are adequate means of making these tyrannies public, they usually disappear before they can come before the committees.

Under some plans the shop committees have been given very extensive authority in matters of discipline. In some cases penalties have been lighter than when the rules were made by

*Abstract of paper delivered before the eighth annual Safety Congre s of the National Safety Council at Cleveland.

the employers, being principally fines and suspension rather than discharges, but in general the added force of censure from fellow employees has reduced the number of offenses. In other cases the penalties have been so severe that the company has been forced to request their modification. One company gives final authority over discharges to an arbitration board from the employees' association. At hearings before this board employees may be represented by council. A rolling-mill company reports greatly improved discipline as a result of a shop committee.

Many concerns report greatly increased coöperation as a result of their works committees. One very definite factor is that representatives take back to the workers a more adequate appreciation of the problems of the management. On the other hand, the management learns something of the problems and ambitions of the employees.

One board of directors authorized the employees to elect a committee to take complete management of about 400 company houses. A certain sum of money was allowed to be spent by the committee in upkeep. While some rather serious blunders were made, the company feels well repaid for the cost.

Several reports showed increased production with no increase, or comparatively small increase, in cost, after the introduction of the representative plan. This was attributed to the better plant spirit brought about by the committees. Other advantages reported included reduction in turnover, in absence, in tardiness, and in wasted time in the shop.

Several reports noted that at the first elections under the plans, a number of "radicals" were chosen. The employees soon learned, however, to distinguish between mere talkers and competent representatives.

Without exception, where a shop committee has been in operation for several months, the company reports that it has revealed capacity for leadership among employees which otherwise would have been suppressed. One company makes it a practice to select assistant foremen from among the employees' representatives.

Some cases have been reported where the more intelligent and fair-minded representatives incurred the distrust of the men because they seemed to side too much with the employers. This shows that too much agreement between committee and management may lead to more trouble than disagreement. It is likely to breed distrust, and that is the main thing these plans are working to abolish.

The study reveals the fact that while the matters of personal grievances are the first questions to come up, the larger questions of policy, shop practice, efficiency, etc., are soon taken up and become the predominating issues.

Installation of Representative Plans

Industrial representation has been successful under such wide variety of conditions that no specific condition seems responsible for success. No two plants will function the same way. A few general suggestions may be valuable, however, for consideration when contemplating the introduction of a plan.

Install a representation plan only during peace times. Trying such a plan in the face of the antagonism present when a strike is threatening or in progress simply invites defeat. It has always worked this way.

Do not impose a ready-made plan. Let the men help work it out gradually. The plan will be better and, what is more important, will be received more favorably.

See that the plan is simple. The joint committee form seems to give best results. Separate meetings should be arranged, however, so that the men may discuss matters without the restraining presence of the "boss."

Some plans are very limited in scope, while others are very broad. Both extremes give trouble. A good way is to start with somewhat narrow limitations and broaden as the committee educates itself.

We advise that every employee, man or woman, citizen or alien, be made to feel that he has a part in the plan's operation. See that everybody understands it. Spare no effort to educate *every* employee. In one plant only citizens had a vote, although of course anyone could present grievances. A group of foreigners struck because they could not understand that they had any share in the plan at all. Make it plain also that the plan does not interfere with membership in unions or with existing relations of the management with the unions.

Keep complete records of meetings and make them accessible to everybody. Usually, the best results follow when meetings are held in working hours. The interest of representatives is held better that way.

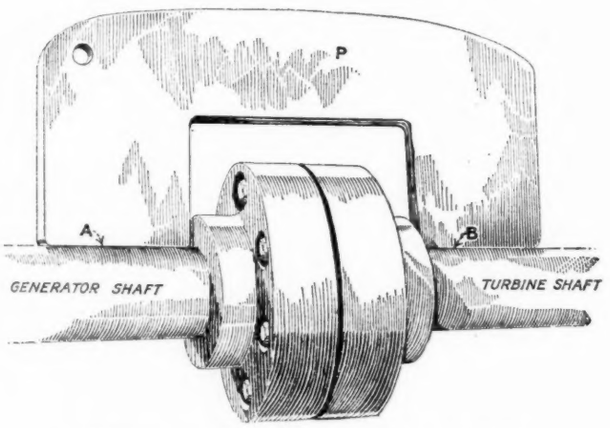
The degree of success or failure of any plan of employees' representation depends not upon its form, the size of the company, the nature of the industry or the character of the working force, but upon the understanding of what the plan means and upon the mutual confidence existing between the employer and employees. There must at least be a foundation of confidence and cordiality if the management and men are to strive together toward an industrial ideal.

The ideal industrial organization is one in which there is friendly coöperation throughout the entire membership with a ready recognition not only of the rights, but the feelings of every member. This result can be attained, not only because it is theoretically sound, but because it has been done.

Balancing and Alignment of the Alternator Rotor

By C. Sylvester, A. M. I. E.E.

The final balancing of alternator rotors must often be done after the machine is permanently erected. In the shop the rotor is balanced, statically and dynamically, before the winding is begun. Any irregularities due to the winding are then taken care of by the balancing weights. These weights are flat pieces of steel free to make in circular grooves, concentric with the shaft, in the end of the rotor. They are held in their proper position by setscrews which are screwed into tapped holes in the bottom of the grooves. There are usually two such weights on each end of the rotor. Excessive vibration of the rotor is sometimes accompanied by firing at the points on the alternator-end shields where the rotor shaft projects through the shields near the slip rings. This simplifies the balancing, as the points that have been in contact will be marked by the firing.



METHOD OF TESTING SHAFT ALIGNMENT

There has been considerable discussion regarding the types of balancing bars used by the various manufacturers. For large rotors the bar should be of box section, having a depth at least one-eighth of its length and sufficient surface on top for a load of 1500 lb. per square inch.

Next to balance, the proper alignment of the rotor shaft is probably the most important feature of the erection work. Checking the alignment of the alternator and turbine rotors is not easy, as a deflection of as much as 0.005 in. is sometimes noted on the bedplate leveling pads after the turbine and generator are put in place.

The illustration shows a scheme for testing the alignment of the two shafts, which has come under the writer's observa-

*Abstract from an article in the *Electrical Review*, London.

tion. A steel plate, marked *P*, is cut so as to pass over the coupling between the turbine and generator shafts. The edges *A* and *B* are carefully ground to a straight line. When the plate is placed in position on the shafts, the alignment will be perfect only if the plate makes contact with the shafts at all points.

The writer remembers a case where the shafts of a 6000-kw. turbo-generator was lined up by the method just described. When run at full speed and full load no lateral movement of the shaft was observed, indicating that the alignment was correct. It was noticed, however, that the oil temperature of the inner bearing was materially increased. This was explained by considering the shaft as a beam supported at three points (the bearings) and loaded at two points (by the generator and turbine rotors). If the bearings are in line, the inner bearing will support about twice its share of the weight. This may be corrected by adjusting the middle bearing so as to be slightly lower than the outer ones.

[Some of the points in the foregoing article seem rather unusual, and *Power* invites discussion from any readers who have had experience along the lines mentioned.—EDITOR.]

Boston Tech Proposes a New Relation with Industry

Big possibilities for the future of American engineering schools are inherent in a plan which the Massachusetts Institute of Technology is now developing to put contributions to its endowment fund upon a sound business basis. The Institute, it may be recalled, is seeking four million dollars from the public in an endowment fund in order to obtain the like amount already promised by the mysterious Mr. Smith, the income from this fund to be used to pay more nearly adequate salaries to the members of its instructing staff. In the quest of this amount, Technology has decided to go before the great industrial corporations and say, in effect: "This Institute is a source of supply of trained men to your organization. You are calling for more and more of these trained men. If this school is to furnish its quota of them, more money must be found somewhere."

The officers of an industrial organization are able to see the full force of the argument. They would like to contribute, but must take a vote of stockholders to comply with the legal technicalities. Contributions must be made before Jan. 1, 1920, to take advantage of Mr. Smith's offer. So the Institute proposes not a contribution, but a contract, something any corporation may enter into by vote of the management.

This contract provides for the payment of an annual fee by the corporation, in return for which the Institute is to permit the corporation to have the use of its library, the opportunity to consult its professors and the first chance of hiring Technology men.

By this new plan the Institute would receive much needed financial assistance and the corporations availing themselves of it would receive technical service the value of which it is difficult to estimate. American industry has long been in need of a clearing house of scientific knowledge. If industry avails itself of the present disposition of the Massachusetts Institute of Technology to become a bureau of research, the importance of the decision will be very far reaching.

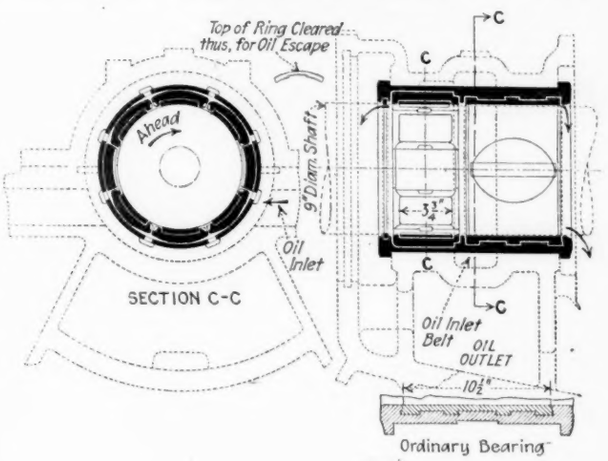
Fears that the Technology proposal may conflict with the work of the consulting engineer are answered by the obvious fact that the problems submitted to the Institute would in general be beyond the scope of the private engineering firms to handle, and by the further fact that the consulting experts of the country are already swamped with the unending questions submitted to them for solution.

The proposition is one that may become a tremendously important factor in determining the position of the United States in the commercial and the economic rivalry of the nations during the next decade.

The Michell Journal Bearing

The following abstract of an article appearing in a recent issue of *The Engineer*, London, should prove of interest as describing the application of a new principle to journal bearings. Up to the present the Michell principle has been used almost exclusively for thrust bearings for marine engines. The bearing surface is made up of a number of so-called pads, each of which is mounted on a pivot so that it is free to take up the proper alignment automatically. After a long series of shop experiments the Engineer-in-Chief of the British Admiralty agreed to the installation of a set of Michell bearings on one turbine of H. M. Destroyer "Makay." For comparison the other turbine was equipped with the ordinary form of bearings.

The construction of the bearing is shown in the cut, where it will be seen that six pads are arranged in a steel shell in the bearing, the tipping being permitted by the reduced curvature of the back of the pads. The total projected area of white metal of the low-pressure Michell bearings is only 20.649 sq. in.,



	MICHELL JOURNAL BEARING	ORDINARY BEARING
Weight on One Bearing	11,328 lb.	11,328 lb.
Projected Area of White Metal	20.649 sq. in.	94.5 sq. in.
Pressure per sq. in. (Projected Area)	549 lb.	120 lb.
Rev. per Minute at Full Power	1,300	1,800
Peripheral Speed per Second	70.5 - ft.	70.5 - ft.

MICHELL JOURNAL BEARING ON H. M. DESTROYER "MAKAY"

as compared with 94.5 sq. in. of the ordinary type of bearing for the same load of 13,328 lb. The pressures on the bearings are 549 lb. per sq. in. and 120 lb. per sq. in. respectively. The cut also shows the comparative sizes of the two types of bearings. As this was an experimental installation, the shells of both bearings were made the same size. The part not occupied by the pads in the Michell bearing is a clearing fit on the shaft and would, of course, be dispensed with in an entirely new design.

An indication of the success of the experiment was given during the two days' progressive trials of the "Makay." The oil came away from the Michell bearing about eighteen degrees cooler than that from the ordinary type.

Another interesting feature was the use of the Michell principle to support the thrust collar and shaft. In this case the outer surface of the thrust collar was used as a journal.

The use of the Michell thrust bearing on the "Makay" permitted the introduction of an ingenious thrust-indicating device. The abutment ring carrying the thrust pads was supported by a number of small rams working in cylinders. These rams were supported in turn by oil under pressure in the cylinders. The pressure necessary to support the rams, of course, gave a measure of the thrust.

Byllesby Properties to Increase Capacity 100,000 Hp.

Rapidly increasing business in territories served by Byllesby electric properties has made imperative additional generating capacity. Three new power stations with a total initial capacity of 33,500 hp. have been planned for immediate construction and further extensions are receiving attention.

One of the new stations will be located in Southern Minnesota, where demands of the Southwestern territory served by the Northern States Power Company have exceeded the capacities of the several divisions concerned. A new steam station will be constructed at this point and one 13,500-hp. steam turbine will be installed. Provision will be made for a second unit of 20,000 hp. to be installed later. Condensing water will be obtained from the Minnesota River and present equipment will include three 1165-hp. boilers with coal and ash handling machinery, etc. The improvement is expected to be completed within a year.

A new station with an initial capacity of 10,000 hp. will be constructed in Western Oklahoma to take care of the growing demands upon the Muskogee, Sapulpa and Drumright Divisions of the Oklahoma Gas & Electrical Company. Condensing water will be obtained from the Arkansas River.

The third station will be constructed at Pueblo, Colo., on the present power house site of the Arkansas Valley Railway Light & Power Company. The present power station with a capacity of 7500 hp. will be maintained and the new station with a present capacity of 10,000 hp. will be constructed adjacent to it. This improvement, like the others, is necessary because of increasing business in present territory and not because of expansion of territory.

Sale of Electric Generator Sets

The Director of Sales announces that the Surplus Property Division, Office of the Quartermaster General of the Army, is offering for sale 400 gasoline-driven electric-generator sets, with switchboards and gasoline tanks, which have been declared surplus by the War Department and on which offers will be received at any time by the Surplus Property Division, Munitions Building, Washington, D. C.

The generator is a 25-kilowatt direct-current commutating pole type. Either 115-volt two-wire or 230-volt three-wire generators can be supplied. The engine is of the closed, four-cycle, single-acting, vertical type, with four cylinders, and is capable of operating the generator at full load indefinitely and at a 25 per cent. overload for two hours. The sets are high-grade in every respect and combine a number of improved safety and gasoline-saving features.

These machines are designed for close regulation, which makes them very desirable for small electric-light and power plants, such as are required by stores, apartment houses, hotels, small factories and even small towns. Owing to the present coal shortage and the curtailment of electric current in many cities and towns throughout the country, these gasoline-driven generators should prove particularly useful as auxiliary or emergency lighting and power equipments.

The sets which the Government is offering for sale are new and have been carefully stored since they were purchased about a year ago. They are packed in the crates in which they were shipped from the factory. They are located at Schenectady, N. Y., and New Cumberland, Penn., and will be shipped promptly upon approval of submitted offers.

Inspection of the machines, switchboards and tanks may be made at the points of storage, or complete specifications may be obtained from the Surplus Property Division, Munitions Building, Washington, D. C. Information relative to the terms of sale, storage points, etc., may be obtained from the same office.

Meeting of the American Welding Society

Friday evening, Dec. 12, the American Welding Society held a meeting in the Engineering Societies Building, New York City, at which discussion of Professor Hudson's theory of arc welding was the chief feature of the program. Comfort Adams, president of the society, was in the chair. Fred E. Rogers, of the Davis-Bournonville Co., was to read a paper "Gas Cutting"; Alfred Kinsey, professor of shop practice, Stevens Institute, prepared a paper entitled, "A Gas-Welding Operation" dealing with gas welding a large pipe which was to be several feet underground. This paper, read by Mr. Mills, of the society, was highly interesting to nearly all branches of engineering. Many of the welds were made aboveground, yet several were made with the pipe in its deep trench. Overhead welds were made.

Mr. Forbes, secretary of the society, gave a brief but illuminating description of Professor Hudson's theory of arc welding. This theory assumes that the metal used to join the parts to be welded is carried to the parts in the form of minute globules, carried against gravity as well as with or or by it. A number of men, distinguished for their active interest in welding, were scheduled to discuss the theory. Three were present: O. H. Eschholz, of the Westinghouse Electric and Manufacturing Co., who led the discussion; C. J. Holslag, Electric Cutting and Welding Co.; and W. E. Ruder, of the General Electric Co. Those who have been interested in the art regretted that D. C. Alexander, of the Quasi Arc Weldtrode Co.; Mr. Armstrong, formerly associated with Mr. Alexander, and Mr. Miller, of Rochester, were not there to participate.

A. J. Deppler, chief engineer, Metal and Thermit Corporation, had a paper with motion pictures on "Thermit in Rail Welding."

Bureau of Mines Annual Report

The Annual Report of the Bureau of Mines to the Secretary of the Interior for the fiscal year 1918-19 has recently been received. Under the heading of "Some Urgent Needs of the Bureau," reference is made to coal-distillation processes and to the petroleum situation. Low-temperature distillation processes are being devised to produce a fuel little if any higher in cost than soft coal, in order to abate the present smoke nuisance. There is need for a clearing house of information as to what is being done in this line as well as for the study of possible byproducts, which alone can make these processes financially successful. The consumption of petroleum and its products is rapidly increasing, but the production of crude oil in the United States probably cannot be increased, and underground reserves are nearly 40 per cent. exhausted. The Bureau has already accomplished a great deal in the elimination of waste in the exploitation of oil and gas and hopes to do considerably more during the coming year.

In the Pittsburgh station of the Bureau, a general survey of the use of powdered coal is planned, with the purpose of issuing a bulletin giving the facts without bias. Many of the published articles on powdered coal were prepared by people interested in manufacturing powdered-coal equipment, and some of this information is misleading. Arrangements have been made for research work to determine how boiler furnaces should be designed to eliminate the troubles at present met in burning powdered coal. Particular attention will be given to the formation of slag in the furnace and to the disposal of ash.

An investigation of the transfer of heat from hot furnace gases to the water of the boiler is under way. The plant for this work consists of a tubular boiler 20 ft. long, and a gas furnace. The temperature of the gases before entering the boiler, along the path of the flow, and after leaving the boiler, and the volume of gases passing into the boiler tubes will be measured precisely. In connection with this work measurements will also be made of the heat transmission through the furnace wall.

In the field of combustion, tests have been made to obtain data as to the effect on the combustion processes of water-cooled surfaces as compared with a firebrick arch. Two types of boiler furnaces, the side-feed and the hand-fired, have been tested at the Pittsburgh station.

The Petroleum Division has assisted several Government organizations in drawing up specifications for the purchase of various grades of motor fuel. The division is represented on a committee whose duties are to standardize specifications for all petroleum products used by Government departments. Other activities of the Petroleum Division included investigations of the production of gasoline from heavier oils by the vapor-phase cracking reaction, also a comparison of motor fuels in supercompression motors. In April, 1919, this division undertook to determine the character of motor gasoline sold throughout the country. About eight hundred samples, collected from all parts of the country, have been analyzed and the results tabulated and classified. This gasoline survey is the most comprehensive that has ever been made and is expected to help materially in the formation of the Government standard specification.

New Publications

BOOK REVIEW

APPLIED SCIENCE FOR METAL WORKERS. By William H. Dooley. Published by Ronald Press Co., New York, 1919. Cloth, 479 pages; 5 x 7 in.; 207 illustrations.

This book is primarily intended for use in technical, industrial, apprentice and continuation schools and for science classes in secondary schools, and covers distinct phases of industrial education, such as elementary mechanics, chemistry, generation of electricity, steam and steam engines, gas engines, machine-shop practice, etc. The subjects are treated in a clear and easy-to-understand manner so that technical and apprentice students will understand the actual work they do in the shop. If there is one criticism that can be made of the book more than any other, it is that the author has attempted to deal with too many subjects within the allotted space, and necessarily the treatment in some cases is superficial. Although this book was written primarily for use in the classroom, the home student will find much in it of interest.

"THE TECH ENGINEERING NEWS." This is the title of a monthly publication to be issued shortly by the undergraduates of the Massachusetts Institute of Technonogy, Cambridge, Mass. The purpose of the paper will be to keep its readers informed of current events of interest in the field of industry, the most recent advances in engineering science and of the results of researches and original investigations.

Obituary

John F. Barker, formerly president of the Gilbert & Barker Manufacturing Co., Springfield, Mass., died of heart failure on Nov. 21. Mr. Barker went to Springfield in 1862 and was employed at the water shops of the United States Armory, where he remained until the founding of the Gilbert & Barker Co. in 1865. He was treasurer and manager of the company until 1884, when he was elected president, which position he held until his retirement in 1911.

Thomas L. Delahunty, secretary and business manager of the Marine Engineers' Beneficial Association, and president of the Marine Workers' Affiliation, died suddenly at Charleston, S. C., on Dec. 14, of heart disease. Mr. Delahunty was born in Charleston, S. C., and at the time of his death was on a visit to his mother. He was 54 years of age. He was educated at the local schools in his home town and followed the sea for 25 years thereafter. For the last 10 years he has been active in the uplift of the marine engineers. Mr. Delahunty was a widower and is survived by his mother, five daughters and two sons.

Charles A. Moore, who was for the past eight years supervising engineer of the Joseph Dixon Crucible Co. and consulting engineer of the American Graphite Co., died at his home in Jersey City on Dec. 5, after a brief illness. Previous to his connection with the Dixon company Mr. Moore was with some of the best-known firms in the Metropolitan district. He was the first chief engineer of the first propeller-driven ferryboat to ply across New York Harbor. He was chief engineer of the Western Electric Co. for six years and chief engineer of the Brooklyn Rapid Transit Co. for nine years. He was born in Maine 64 years ago, but spent the greater part of his life in the vicinity of New York. He is survived by his widow, two daughters, one son and five grandchildren.

H. L. Gantt, well-known industrial engineer, died at his home in Montclair, N. J., on Nov. 23. He was born in Calvert County, Maryland, May 20, 1861. He was educated at the McDonogh School, Baltimore, Md.; in 1880 he took the degree of A. B. at Johns Hopkins University, and in 1884 the degree of M. E. at the Stevens Institute of Technology. Since 1884 he has specialized in the field of industrial management, and has been celebrated throughout America for much original and brilliant work in this line. He was the author of several books and articles on industrial-management problems. One of the most important contributions to the literature of management is his book, "Work, Wages and Profits." He was a member of the American Society of Mechanical Engineers, was manager 1908-11 and vice-president 1913-15. He was also a member of the Society of Naval Architects and Marine Engineers, American Geographic Society and Beta Theta Pi. He belonged to the Engineers' Club, Machinery Club and Johns Hopkins Club. For some time he has had a consulting office in the Singer Building, New York City.

Personals

Albert A. Casey has joined the sales engineering staff of the American Steam Conveyor Corp. at Cincinnati, Ohio, which territory is under the managership of Henry P. Thompson.

George A. Miller, after completing a course in mechanical engineering at the Kansas State Agricultural College, has become connected with the turbine-research department of the General Electric Co., at Lynn, Mass.

Fred D. Harger, former manager of the F. D. Harger Co., of Buffalo, has accepted a position as vice-president and general manager with the Mono Corporation of America, 257 Washington St., Coal and Iron Exchange, Buffalo, N. Y.

Charles B. Hart, for some time superintendent of the light and power department of the Fort Wayne & Northern Indiana Traction Co., has been appointed chairman of the commercial section of the Indiana Electric Light Association.

H. G. Bain, until recently attached to the San Francisco sales office of the Midvale Steel and Ordnance Co., is now a member of the Tacony Steel Co.'s sales organization and will represent that company in the upper part of New York State.

George M. Brill, who before joining the United States service two years ago, specialized in industrial-plant management, will resume his practice in New York City, at Room 2607, Singer Building, until May 1, 1920, when he will remove to the Guaranty Fifth Avenue Building.

John E. MacDonald, formerly Chicago manager of the vapor heating department of the Illinois Engineering Co., has become associated with the Coon-De Visser Co., Detroit, Mich. Mr. MacDonald is one of the pioneers in the development of apparatus designed for vapor and vacuum heating.

Dr. F. G. Cottrell, chief metallurgist of the Bureau of Mines and inventor of the Cottrell process for utilizing smelter fume by extraction of arsenic and various other commercial chemicals from the noxious gases, has been named assistant director in charge of all investigative and scientific work.

Lieut. Col. Jess E. Jurgensen, who while engineer of the St. Regis Hotel in New York, instituted systems of training and education which have endeared him to many New Yorkers, is management engineer of the Acme White Lead and Color Works, at Detroit, Mich., having accepted that position on his discharge from the army.

Myron T. H. Blanchard, lately with the Hydraulic Pressed Steel Co., is a recent addition to the Cleveland sales force of the Tacony Steel Co. Mr. Blanchard has had considerable metallurgical experience, having been connected with the metallurgical departments of the Bethlehem Steel Co. and the Canton Spring and Axle Co. of Cleveland.

Charles Eugene Schneider, president of the French Industrial Commission to the United States, had the honorary degree of doctor of engineering conferred upon him on Nov. 24, by Dr. Alexander C. Humphreys, president of the board of trustees of Stevens Institute of Technology, Hoboken, N. J., before representatives of the various branches of the engineering profession.

N. H. Holifield, for several years superintendent of the Laurel Light and Railway Co., and J. J. Mundell, for a number of years head bookkeeper for the same concern, have left for Jennings, La., where they have invested in a rice plantation and will engage in farming. Mr. Holifield began work with the company as a laborer and assisted in the erection of the power plant. John Bagley, of McComb City, will succeed him.

W. W. Freeman has been unanimously elected president of the Society for Electrical Development, succeeding Henry L. Doherty, who has held the office since the founding of the society nearly six years ago. Mr. Freeman is well known to all branches of the electrical industry. He is president of the Union Gas and Electric Co., of Cincinnati, Ohio, and has been successively chairman and vice-chairman of the Public Policy Committee of the National Electric Light Association for a number of years.

Russell W. Stovel, who recently returned from France,, where as lieutenant-colonel of engineers, he served as chief of the Terminal Facilities Division of the Army Transport Service, has been appointed a consulting engineer of Westinghouse Church Kerr and Co., Inc., and, as a member of that organization, will devote his entire time to the company's electrical and mechanical work. Mr. Stovel has had an unusually comprehensive experience in the electric and mechanical problems connected with central power-station and steam-railroad electrification work. He was graduated from McGill University in 1897 with the degree of electrical engineer, and the following year entered the employ of Westinghouse Church Kerr & Co. He soon became an assistant engineer, then successively engineer-in-charge and mechanical engineer of the company, and finally a managing engineer. In 1914 Mr. Stovel left the Westinghouse Co. to become managing engineer for Gibbs & Hill, consulting engineers, of New York. For this company he had direct charge of the Paoli and Chestnut Hill electrifications of the Pennsylvania RR., the Elkhorn Grade electrification of the Norfolk & Western Ry., and the electrification of the New York Connecting Ry.

M. S. Sloan, president of the Brooklyn (N. Y.) Edison Co., has accepted the appointment by President R. H. Ballard of the National Electric Light Association, as chairman of the committee on Electrical Resources of the Nation. Mr. Sloan is organizing a committee to handle this great subject, representative of all branches of the industry. The committee's report, to be presented at the annual convention to be held in Pasadena, Calif., May 18-21, 1920, will be of inestimable value to the industry at large, and in the nature of a textbook be of particular assistance to the small companies throughout the country. The present status of electrical development in the United States, both private and municipal, will be noted, and the comparisons drawn between different sections of the country, and between private and municipal operation, should prove to be very interesting.

R. H. Ballard, president of the National Electric Light Association, reports that Frank M. Kerr, vice-president and general manager of the Montana Power Co., has accepted the chairmanship of the committee on Steam Railroad Electrification. The Montana Power Co., of which Mr. Kerr is the operating executive, is now furnishing the power supply for the operation of 657 miles of Chicago, Milwaukee & St. Paul RR. in Montana and the Pacific Northwest, and consequently he is in a position to speak with authority on the subject of railroad electrification from a practical standpoint. R. Beeuwkes, electrical engineer of the Chicago, Milwaukee & St. Paul RR., will act with Mr. Kerr on this committee, and the additional members will be from other power companies, manufacturers and banking institutions, so that every phase of this great subject will be intelligently handled in the report of the committee which will be submitted at the Pasadena, California, convention, May 18 to 21, 1920.

Joseph G. Worker, for many years manager of the Stoker Division, Westinghouse Electric and Manufacturing Co., will, on Jan. 1, 1920, assume the duties of general

manager of the Phoenix Manufacturing Co., Eau Claire, Wis., having general supervision of sales, engineering and production. The Phoenix Manufacturing Co. was established in 1861 as a partnership, and incorporated in 1875. It manufactures high-class machine tools, sawmill machinery, tractors and other machinery. In 1905 Mr. Worker left Deere & Co., manufacturers of agricultural implements, and entered the employ of the Westinghouse Machine Co. as stoker erector. In February, 1906, he was transferred to the New York office as assistant district stoker superintendent. In May, 1907, he left the Westinghouse Machine Co., entering the employ of the Calumet Steel Co., to assist the general superintendent in the construction of a steel rolling mill. Jan. 1, 1908, after the above mill was completed, he left the employ of the Calumet Steel Co. and reëntered the employ of the Westinghouse Machine Co. as assistant supervising engineer of the stoker department. In August, 1910, he was appointed engineer, stoker department, for the Western District. Aug. 1, 1915, he was appointed manager of stoker section, power department, Westinghouse Electric and Manufacturing Co.

Engineering Affairs

The American Society of Mechanical Engineers will hold its next meeting at St. Louis, Mo., May 24-27 inclusive.

The New England Water Works Association will hold a meeting on Dec. 10 at the Hotel Brunswick, Boston, Mass.

The American Electric Railway Association will hold its mid-year meeting and dinner at the Hotel Hollenden, Cleveland, Ohio, Jan. 8. An attractive program is being arranged.

The American Association for the Advancement of Science will hold its forty-second meeting at St. Louis, Mo., Dec. 29-Jan. 3, with headquarters at the Soldan High School.

The Association of Iron and Steel Electrical Engineers, Philadelphia Section, will hold a meeting on Jan. 3, 1920. J. D. Wright, electrical engineer, power and mining division, engineering department, General Electric Co., will present a paper on "Electric Mill Drives."

The American Society of Mechanical Engineers, Boston Section, held a joint session with the Boston Section of the American Institute of Electrical Engineers on Dec. 16, when inspection of the Watertown Arsenal and the laboratory of the new Harvard Engineering school was made. Prof. Albert Sauveur, of Harvard University, spoke after the dinner at the Harvard Union, on "Metallography and Heat Treatment of Metals."

The American Society of Heating and Ventilating Engineers will hold its annual meeting in New York City, Jan. 27-29. Among the many interesting papers to be presented are the following: "Oil as a Fuel for Boilers and Furnaces," by H. H. Fleming, engineer of the fuel-oil department of the Standard Oil Co.: "Relation of Boiler-Heating Surface Area to Boiler Capacity," by P. J. Dougherty; "Color Schemes for Distinguishing Plant Piping," by H. L. Wilkinson.

The National Electric Light Association, Inductive Interference Committee, held its second meeting in Denver, Colo., Dec. 1-3, 1919. The meeting was well attended by members from all parts of the country. Some of the sessions were devoted to a continuation of the attention given at the Chicago meeting in September to organizing for the work in hand, including the establishing of a centralized agency to assist power companies to effective coöperative efforts and a better understanding in meeting the difficult problems of the inductive interference situation, a situation continually increasing in proportion with the rapid multiplying of power and communication circuits. Other sessions were given to the subcommittee work in analyzing and compiling information gathered pertinent to the situation and to consideration of requests from several localities for advice in meeting specific and active inductive interference problems.

Miscellaneous News

A Refrigerator Fleet is to be formed in Italy by requisitioning six German refrigerator steamers and transforming three Italian steamers temporarily into refrigerators. These nine vessels will be capable of transporting 17,000 tons of frozen meat.

The Franklin Institute, acting through its Committee on Science and the Arts, has awarded its Edward Longstreth Medal of Merit to John Walter Ledoux of Swarthmore, Pa., for the Simplex Venturi meter manufactured by the Simplex Valve and Meter Co., of Philadelphia.

The National Electric Light Association's Overhead Systems Committee is planning in its 1920 report to bring to the attention of the industry any new devices that, in the committee's opinion, would be useful in line construction or line maintenance work. In order to make the report as useful as possible, the committee would be glad to get in touch with any manufacturers making such tools or devices for use in overhead line work. It is not the committee's plan to include in its report anything whatever regarding the various lines of standard fixtures that are on the market, but to call attention to special articles that might prove of particular value to operating companies. Any data regarding such items should be sent to W. K. Vanderpoel, Chairman of the Overhead Systems Committee, at 80 Park Place, Newark, N. J.

Vibration of buildings is an interesting subject to the power-plant engineer. It is one of the practical difficulties that confront him in his everyday work and one upon which little published information is available. The Aberthaw Construction Co., of 27 School St., Boston, started an investigation of the subject, and published a preliminary report in 1916, but our entry into the war put a summary stop to the work. It has now been taken up again, and the company would welcome any contribution to the knowledge upon the subject, or any account of experiences which might aid in its investigation and solution. We are sure that our readers will be glad to place any information or suggestions at their command in the possession of the company and shall look forward with interest to see what the investigation may develop.

Business Items

The Arrow Engineering Co., of Chicago, will hereafter represent the National Pipe Bending Co., of New Haven.

The Erie Engine Works, Erie, Penn., announces the opening of a new Philadelphia sales office at 1304 Pennsylvania Building, with Otto C. Reymann in charge.

The Sterling Blower Co., Hartford, Conn., has opened an office in Philadelphia to take care of its growing business in that territory.

The American Fabrics Co., Bridgeport, Conn., announces that it has acquired the entire business heretofore conducted under the name of International Textile, Inc.

The Link-Belt Co., on account of its growing business, is contemplating an extension to its Belmont factory, and in time completing its new furnace buildings, Nos. 7 and 8.

The Van Dorn Electric Tool Co., Cleveland, Ohio, on account of its growing business, is having a new four-story building put up, with 30,000 additional feet of floor space.

Mono Corporation of America, Buffalo, N. Y., has recently incorporated, and has engaged space for offices, stockrooms, service department and laboratory, on the fifth floor of the Coal and Iron Exchange, at 257 Washington St., Buffalo, N. Y.

The Bound Brook (N. J.) Oil-less Bearing Co. has completed another new building as an addition to its plant. A new power plant has also been added as well as a new office building. The new building adjoins the foundry which was completed in 1917.

The Black & Decker Manufacturing Co., Baltimore, Md., has opened an additional office on the Pacific Coast, at 201 Maynard Building, Seattle, Wash., in charge of A. E. Nordwall, who will have charge of the distribution of the company's products in the State of Washington, working under the direction of the main Pacific Coast office, 918 Hearst Building, San Francisco.

The Petroleum Heating and Power Co has been organized, with $2,000,000 capital, by Boston and New York men, to take over the Fess Rotary Oil Burner, Inc. The company is engaged in the installation of burners and supplying of fuel oil by means of a fleet of motor trucks, each with a capacity equivalent to ten tons of coal, and covering Boston and Providence suburbs. It is planned to start similar services at New York, Philadelphia, Washington and other cities along the Atlantic seaboard.

Jenkins Bros., it is announced, will, in the near future, increase their manufacturing facilities by owning and operating a plant in Bridgeport, Conn. This plant will be devoted entirely to the manufacture of the Jenkins valve. To take care of the company's rapidly increasing business abroad, the Canadian branch, Jenkins Bros., Ltd., Montreal, has recently completed alterations and additions to its brass valve department and now has in course of construction a new 192 x 80 ft. iron valve foundry.

The Hays School of Combustion announces that W. L. Abbott, chief operating engineer of the Commonwealth Edison Co., Chicago, has become associated with the course in combustion engineering as reviewing and advisory editor. Mr. Abbott's position in the power-plant operating field will add weight and authority along operating lines to the teachings of the institution and will round out the faculty, which includes, besides Joseph W. Hays, the author of the course, the following well-known men: Joseph Harrington, Fred R. Low, David Moffat Myers, S W. Parr and Arthur L. Rice.

The Hooven, Owens, Rentschler Co., Hamilton, Ohio, has opened two new offices and has made some changes in the personnel of its other offices as follows: A new office has been opened in Philadelphia at 2129 Land Title Building, and C. M. Decker, formerly with R. D. Wood Co. has been made manager. A new office has also been opened at Richmond, Va., with E. H. Fairchild, formerly of the C. & G. Cooper Co., in charge. E. S. Cooley, formerly with the Fall River Ship Building Co., is now connected with the New York office of the company. Henry E. Balsley, formerly with the American Bridge Co., has been made manager of the Chicago office. R. G. Holman, formerly with the General Electric Co., centrifugal department, is now associated with the company in charge of all blowing engines.

Trade Catalogs

The Star Brass Works, Chicago, Ill., has issued a new 12-page bulletin, No. 6, pertaining to its line of small steam- and water-jet apparatus, small steam-jet pumps, etc., fully illustrated: valuable engineering data also included. Copy free upon request.

J. E. Rhoads & Sons, Philadelphia, Penn., has issued a new edition of its "Belt User's Book," which contains some valuable information, rules and suggestions to users of leather belting. A horsepower table for leather belting is also given. The book is a distinct improvement on the one previously issued and may be had free upon request.

The Under-Feed Stoker Co. of America, Detroit, Mich., has issued a 31-page booklet on "Coal." This gives very complete information covering proximate and ultimate analysis of coals from every mining section in the United States, as well as other valuable information on coal and coal consumption. Copies of the booklet may be had free upon request.

Ont., Toronto—A. D. Gorrie & Co., Ltd., has awarded the contract for the construction of a 4 story, 75 x 115 ft. garage on Victoria St., to T. E. Essery, Confederation Life Bldg. A heating system will be installed in same. Total estimated cost, $125,000.

The Nelson Valve Co., Philadelphia, Penn., has issued a 156-page leather-bound catalog and price list, No. 10, on "Nelson Valves." This catalog is fully illustrated and describes in detail bronze, iron, and steel valves in gate, globe, check and non-return patterns, including types for practically every class of service in power plant work, industrial establishments and large building construction.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$8.20@$8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	3.60@ 3.80
Rice	2.30@ 2.50
Barley	1.25

Bituminous

	Clearfields	Cambrias and Somersets
f.o.b. mines, net tons	$2.85@$3.35	$3.15@$3.60
F.o.b. Philadelphia, gross tons	5.05@ 5.60	5.35@ 5.90
F.o.b. New York, gross tons	5.40@ 5.95	5.75@ 6.25
Alongside Boston (water coal), gross tons	7.00@ 7.75	7.60@ 8.00

Pocahontas and New River are practically off the market for coastwise shipment, but are quoted at $6.25@$7.00.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

Anthracite

	Company Coal
Broken	$7.80@$8.25
Egg	8.20@ 8.65
Stove	8.45@ 9.05
Chestnut	8.55@ 9.05
Pea	7.05@ 7.40
Buckwheat	5.15
Rice	4.50
Barley	4.85
Boiler	4.85

Bituminous

	Spot
South Fork (best)	$3.25@$3.50
Cambria (best)	3.00@ 3.25
Cambria (ordinary)	2.60@ 2.90
Clearfield (best)	3.00@ 3.25
Clearfield (ordinary)	2.60@ 2.90
Reynoldsville	2.85@ 2.90
Quemahoning	3.25@ 3.50
Somerset (medium)	3.00@ 3.25
Somerset (poor)	2.50@ 2.75
Western Maryland	2.50@ 2.75
Fairmont	2.25@ 2.50
Latrobe	2.60@ 2.90
Greensburg	2.75@ 3.00
Westmoreland ¾ in.	3.40@ 3.50
Westmoreland run-of-mine	2.75@ 3.00

PHILADELPHIA—Anthracite prices are practically the same as those listed above for New York. Bituminous coal prices vary according to district from which they are mined. For ordinary slack the price is $2.45@$2.55; lump, $3.00@$3.35.

BUFFALO—

Anthracite

	On Cars, Gross Ton	At Curb, Net Ton
Grate	$8.55	$10.80
Egg	8.80	10.65
Stove	9.00	10.85
Chestnut	9.10	10.85
Pea	7.75	9.30
Buckwheat	5.70	7.75

Bituminous

Allegheny Valley	$4.80
Pittsburgh	4.65
No. 8 Lump	4.65
Mine Run	4.80
Slack	4.10
Smokeless	4.60
Pennsylvania Smithing	5.70

CLEVELAND—Prices of coal per net ton delivered in Cleveland are:

Anthracite

Egg	$11.75@$11.90
Chestnut	12.00@ 12.00
Grate	11.75@ 11.90
Stove	11.90@ 12.10

Pocahontas

Mine-run	$7.50

Domestic Bituminous

West Virginia splint	$8.50
No. 8 Pittsburgh	$6.60@ 6.90
Mastilon lump	8.25@ 8.50
Coshocton lump	7.15

Steam Coal

No. 6 slack	$5.25@$5.50
No. 8 slack	5.10@ 5.50
Youghiogheny slack	5.25@ 5.50
No. 8 ¾ in.	5.70@ 6.00
No. 6 mine-run	5.25@ 5.50
No. 8 mine-run	5.75

Only coal available is mine-run Pocahontas.

MIDDLE WEST—Chicago quotations, F.o.b. cars at mine:

	Springfield Carterville Williamson Franklin Saline Harrisburg	Fulton Peoria	Grundy La Salle Bureau Will
Lump	$2.55@$2.70	$2.95@$3.10	$3.25@$3.40
Washed	2.75@ 2.90		3.45@ 3.60
Mine Run	2.35@ 2.50	2.75@ 2.90	3.00@ 3.15
Screenings	2.05@ 2.20	2.35@ 2.50	2.75@ 2.90

New Construction

PROPOSED WORK

Conn., Bridgeport—The United Illuminating Co., 84 Temple St., New Haven, plans to construct a power station on Congress St., to develop 30,000 kw. (ultimately 100,000 kw.), six battery, 750 h.p. B. & W. boilers, 200% rating, and three 10,000 kw. turbines (probably G. E.) will be installed in same. Total estimated cost, $1,500,000. Westcott & Mapes, 207 Orange St., New Haven, Engrs.

Conn., Bristol—The Board of Education is having plans prepared for the construction of a 3 story high school. A steam heating system will be installed in same. Total estimated cost, $600,000. Wilson Potter, 22 East 17th St., New York City, Arch. and Engr.

Conn., Meriden—The Y. M. C. A., 21-23 Colony St., will soon award the contract for the construction of a 4 story, 138 x 138 ft. building on West Main St. A. Kriebel vapor vacuum system will be installed in same. Total estimated cost, $360,000. Jallade, Lindsay & Warren, 37 Liberty St., New York City, Archs.

Conn., South Norwalk—J. C. Schaeffler, Arch. and Engr., 40 West 32nd St., New York City, is preparing plans for the construction of a factory. A steam heating system will be installed in same. Total estimated cost, $150,000. Owner's name withheld.

Conn., Waterbury—Cross & Cross, Archs., 681 5th Ave., New York City, will soon award the contract for the construction of an isolation hospital on Watertown Ave., for the city. A steam heating system will be installed in same. Total estimated cost, $200,000.

Conn., Windsor—The General Electric Co. plans to build an addition to its plant, here. Estimated cost, $75,000. A. A. Bailey, Gen. Mgr.

N. Y., Buffalo—The Daily Bread Co. is having plans prepared for the construction of a 3 story bakery. A steam heating system will be installed in same. Total estimated cost, $200,000. L. S. Beardsley, 40 West 32nd St., New York City, Arch. and Engr.

N. Y., Churchville—Alderman, Fairchild & Co., 367 Orchard St., Rochester, manufacturers of paper boxes, plan to build a 1 story, 63 x 233 ft. building on East Buffalo St. An electric power plant and transmission machinery will be installed in same. Total estimated cost, $95,000.

N. Y., Fulton—The Board of Education plans to build a 2 story high school. A steam heating system will be installed in same. Total estimated cost, $225,000. Wilson Potter, 22 East 17th St., New York City, Arch. and Engr.

N. Y., Lake Placid—The Stevens Hotel Co. plans to construct a fireproof addition. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., New York—G. A. and H. Boehm, 7 West 42nd St., is in the market for oil burning devices for low pressure steam plants.

N. Y., New York—Euvrard, Sambach & Euvrard, Archs. and Engrs., 29 Cleveland Pl., are preparing plans for the construction of a 7 story loft building at 48-50 West 36th St. A steam heating system will be installed in same. Total estimated cost, $400,000. Owner's name withheld.

N. Y., New York—The International Sporting Club, c/o W. H. Gompert, Arch. and Engr., 171 Madison Ave., is having plans prepared for the construction of a 9 story club house on 49th St. and Lexington Ave. A steam heating system will be installed in same. Total estimated cost, $600,000.

N. Y., New York—A. E. Lefcourt & Co., 140 Madison Ave., is having plans prepared for the construction of a 12 story, 100 x 200 ft. office and loft building at 223 West 38th St. A steam heating system will be installed in same. George and Edward Blum, 505 5th Ave., Archs. and Engrs.

N. Y., New York—The New Pine St. Realty Co., 31-33 Pine St., will build a 4 story bank and office building. A steam heating system will be installed in same. Total estimated cost, $200,000. Work will be done by day labor.

N. Y., New York—J. C. Schaeffler, Arch. and Engr., 40 West 32nd St., is preparing plans for the construction of a loft building at 539-549 Broome St. A steam heating system will be installed in same., Total estimated cost, $150,000. Owner's name withheld.

N. Y., Ontario—The Ontario Storage Corporation plans to construct a cold storage plant and install ice-making machinery in same. Total estimated cost, $150,000. J. S. Albright, Pres.

N. Y., Peekskill—The Baron de Hirsch School, 222 East 64th St., New York City, is having plans prepared for the construction of a 1 story power house. Estimated cost, $150,000. E. I. Shire, 373 4th Ave., New York City, Engr.

N. J., Hoboken—H. R. Mallinson & Co., Woolsley Ave., Long Island City, is having plans prepared for the construction of a silk mill. A steam heating system will be installed in same. Total estimated cost, $200,000. Lockwood, Green & Co., 101 Park Ave., New York City, Archs. and Engrs.

Pa., Hazelton—The citizens have approved a loan of $250,000 for the completion of two school buildings. Contracts will be let for installing heating, lighting and ventilating systems in same.

Pa., Philadelphia—The Department of Health & Charities, City Hall, has awarded the contract for installing heating system in the proposed 2 and 3 story additions to hospital buildings, on Luzerne and 2nd Sts., to Charles E. Munday & Co. Total estimated cost, $200,000.

Pa., Philadelphia—Paul Monaghan, Arch., 1218 Chestnut St., will soon award the contract for the construction of a 3 story, 49 x 125 ft. high school on 49th and Chestnut Sts., for the West Philadelphia Catholic High School, 49th and Chestnut Sts. A steam heating system will be installed in same.

Pa., Philadelphia—Frank V. Nickels, Arch., 4400 Manayunk St., will soon award the contract for the construction of a 3 story, 80 x 225 ft. factory on Boynton and Chelton Aves. A steam heating system will be installed in same. Total estimated cost, $90,000. Owner's name withheld.

Pa., Scranton—The United Service Co., Scranton Life Bldg., is in the market for boiler room equipment and accessories.

Pa., Philadelphia—The Board of Education, Keystone Bldg., plans to build two 3 story, 115 x 165 ft. grade schools; one on 70th and Buist St. and the other on 9th and Oregon St. Steam heating systems will be installed in same. Total estimated cost, between $880,000 and $1,000,000.

Pa., Wilkes Barre—The Goldsmith Silk Co. plans to construct a 3 story, 300 x 400 ft. silk mill on Blackman St. A steam heating system and boiler plant will be installed in same. Total estimated cost, $500,000.

Pa., Wilkes-Barre—The Kitsee Battery Co., 62 North Main St., is having plans prepared for the construction of a 3 story, 80 x 150 ft. storage battery factory on North Main St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Del., Middletown—W. E. Hance, Arch., 1619 Chestnut St., will receive bids about February 1 for the construction of a 2 story, 100 x 140 ft. school for the Board of Education. A steam heating system will be installed in same. Total estimated cost, $100,000.

N. C., Statesville—The Statesville Hotel Co. plans to construct a 5 story, 40 x 120 ft. hotel. A low pressure steam heating system will be installed in same. Total estimated cost, $150,000. Louis H. Asbury, Realty Bldg., Charlotte, Arch.

S. C., Charleston—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the installation of a heating system in the torpedo storehouse building No. 101, and for the construction of a boiler house addition to the same, at the Naval Ammunition Depot, here.

La., Monroe—The city has voted $1,450,000 bonds, part of which will be used for the construction of an electric power plant, including turbo-generators, 1000 kw. capacity, with condensers, superheaters for present boilers, resetting present boilers and a brick and concrete chimney; also improvements to waterworks, including centrifugal raw water pumps, service pumps with a 4,000,000 gal. capacity, etc.

Tenn., Memphis—The Sugar Products Co., 16 Exchange Pl., New York City, plans to construct a molasses storage building to house a 500,000 gal. tank, power plant, pumping and transferring equipment. Estimated cost, $50,000.

Ohio, Cincinnati—The city plans to install new boilers in the Main River pumping stations and boiler equipment in the Western Hills Station. Total estimated cost, $380,000. Frank Krug, City Hall, Engr.

Ohio, Cleveland—The Grace Hospital Association, 2307 West 14th St., is preparing plans for the construction of a 5 story, 100 x 280 ft. hospital on West 14th St. A steam power plant, consisting of one 300 h.p. boiler with stokers, feed water pumps, blowers, oil separators, air compressors, etc., will be installed in same. Total estimated cost, $500,000. W. S. Longee, Marshall Bldg., Arch.

Ohio, Dayton—The Dayton Power & Light Co., Home Telephone Bldg., plans to double the capacity of its plant at Millers Ford, near here. The total capacity of the plant, when additional equipment is installed, will be 60,000 h.p. O. H. Hutchings, Gen. Mgr. Total estimated cost, $800,000.

Ohio, Dayton—The Jefferson Main St. Market Co. plans to build a 4 story, 50 x 400 ft. market building on South Main St. Two elevators and a cold sorage plant will be installed in same. Total estimated cost, $500,000. Joseph Lowes, Schwind Bldg., Arch.

Ohio, Dayton—The Peckham Coal & Ice Co., Daller and Chapel Sts., plans to build a 2 story, 100 x 110 ft., 75 ton ice manufacturing plant, on Linden Ave. Estimated cost, $70,000.

Ohio, East Liverpool—The Ohio River Power Co. is having plans prepared for the construction of a transformer sub-station with connecting buildings. Total estimated cost, $600,000.

Ind., Indianapolis—George C. Hitt, Business Director, will soon award the contract for the construction of a 3 story Arsenal Technical High School for the Board of School Commissioners, Meridian and Ohio Sts. A steam heating system will be installed in same. Total estimated cost, $700,000. Snider & Rotz, Merchants Bank Bldg., Engrs. Vonnegut, Bohn & Miller, Indiana Trust Bldg., Archs.

Ind., Princeton—The Commissioners of the Patoka Wabash Drainage and Levee District have retained T. W. Jacob, Boatmen's Bank Bldg., St. Louis, Mo., to make investigations and submit a report for the construction of a 38 mile levee with flood gates and pumping station.

Mich., Adrian—The State Industrial Home for Girls engaged Robert Ernst, Engr., 35 Bagg St., Detroit, to submit preliminary estimates for installation of heating equipment in plant to heat administration building and surrounding buildings.

Mich., Detroit—I. Applebaum, 2023 Dime Bank Bldg., engaged Alvin F. Harley, Arch., Kresge Bldg., to prepare plans for the construction of a 3 story, 76 x 180 ft. factory on Russell St. near Medbury St. A steam heating system and electric motors for power will be installed in same. Total estimated cost, $100,000.

Mich., Detroit—The Board of Education, 50 Broadway, received bids for the installation of a heating, ventilating and plumbing system in the proposed 150 x 211 ft. school on Maplewood and Spokane Aves., from Irvine & Meier, 2289 Woodward Ave., $81,682; J. W. Partlan, 51 Park Place, $90,346; W. J. Rewoldt, 506 Owen Bldg., $90,860.

Mich., Detroit—The Board of Education, 50 Broadway, is having plans prepared for the construction of a 3 story, 100 x 250 ft. school at Goldberg Athletic Field. A Plenum steam heating system, consisting of boiler, fans and pump, will be installed in same. Total estimated cost, $400,000. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archs.

Mich., Detroit—The city received bids for the construction of 7 mi. Rd. sewer and a temporary pumping station, with electrically operated pumps, from C. A. Handyside, 833 Lothrop Ave., $26,600; Power Plant Supply Co., Chamber of Commerce, $29,980.

Mich., Detroit—Louis Kamper, Arch., Book Bldg., is preparing plans for the construction of a 2 story, 58 x 72 ft. bank building on Gratiot Ave. near Jos. Campau Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. Owner's name withheld.

Mich., Detroit—The Nativity Church, c/o Rev. F. Heidenich, McClellan Ave., is having plans prepared for the construction of a 2 story church on McClellan Ave. near Lamb Ave. A steam heating system will be installed in same. Total estimated cost, $175,000. Van Leyden, Schilling & Keough, Union Trust Bldg., Archs. and Engrs.

Mich., Flint—Van Leyen, Schilling & Keough, Archs. and Engrs., 201 Walsh Bldg., plan to construct a 1 story, 30 x 248 ft. coal storage building on Industrial Ave. Electric motors will be installed in same. Total estimated cost, $35,000. Owner's name withheld.

Mich., Ford City (Wyandotte P. O.)—The Board of Education has engaged J. G. Kastler & Co., Arch., 523 Chamber of Commerce, Detroit, to prepare plans for the construction of a 2 story school on Main St. Steam heating equipment will be installed in same. Total estimated cost, $150,000.

Mich., Grand Rapids—Our Lady of Sorrows Parish, c/o Rev. Salvatore Clanci, engaged Harry L. Mead, Arch., Houseman Bldg., to prepare plans for the construction of a 2 story church and school. A steam heating syetem will be installed in same. Total estimated cost, $175,000.

Mich., Jackson—The First Methodist Episcopal Church retained W. E. N. Hunter, Arch., 1306 Chamber of Commerce, Detroit, to prepare plans for the construction of a 2 story community house. Steam heating equipment will be installed in same. Total estimated cost, $200,000.

Ill., Chicago—The Hollander Fireproof Storage Co., 1616 Milwaukee Ave., is having plans prepared for the construction of a 7 story, 75 x 130 ft. storage warehouse on Lawrence and North Sawyer Aves. A steam heating system and refrigeration plant will be installed in same. Total estimated cost, $250,000. Moores & Dunford, 38 South Dearborn St., Engrs.

Wis., Milwaukee—W. S. Seaman Co., 480 Virginia St., has purchased a site and plans to build a 6 story, 100 x 400 ft. and 50 x 70 ft. factory on Port Washington Rd. Estimated cost, $500,000. A steam power plant will be erected.

Wis., Milwaukee—The A. O. Smith Corporation, 27th and Keefe Ave., has had plans prepared for the construction of a 2 and 6 story, 365 x 850 ft. factory. A steam heating system will be installed in same. Total estimated cost, $1,500,000. H. J. Esser, Camp Bldg., Arch and Engr.

Wis., Tomah—The Board of Education is having plans prepared for the construction of a 3 story, 50 x 60 ft. addition to high school and central heating plant. Plans include 700 ft. heating tunnel. Total estimated cost, $60,000. H. C. Haeuser, Colby-Abbot Bldg., Milwaukee, Arch. and Engr.

Minn., Coleraine—A. King, Secy. of the Board of Education, will receive bids in March for the construction of a 2 story, 150 x 270 ft. high school in the Canistes District. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $500,000. W. T. Bray, Torrey Bldg., Duluth, Arch. and Engr.

Minn., Duluth—The Y. M. C. A., 3rd Ave., Duluth, will soon award the contract for the construction of a 3 story, 75 x 113 ft. building on Central Ave. A steam heating system will be installed in same. Total estimated cost, $100,000. B. C. Wade, Y. M. C. A. Bldg., Duluth, Secy. German & Jenssen, Exchange Bldg., Archs. and Engrs.

Minn., Ellsworth—The town is having plans prepared for new electric-light equipment. Estimated cost, $10,000. Druar & Smith, Globe Bldg., St. Paul, Engrs.

Minn., Hastings—The State Board of Control, Capitol, St. Paul, will soon award the contract for the construction of a 1 story, 45 x 140 ft. power plant and is in the market for equipment for same. Total estimated cost, $125,000. C. L. Pillsbury Co., Metropolitan Bank Bldg., Minneapolis, Engr.

Minn., Hopkins—The village plans to construct a well about 750 ft. deep, and install pumping machinery. Estimated cost, $20,000. J. W. Schaffer, Engr.

Minn., New Ulm—The Eagle Rolling Mill Co. will soon award the contract for furnishing rolling equipment, including boilers, crane and coal handler. Estimated cost, $35,000. C. L. Pillsbury Co., Metropolitan Life Bldg., Minneapolis, Engr.

Minn., Minneapolis—L. S. Donaldson Co., 601 Nicollet Ave., plans to construct a 6 story addition to its present department store on 7th St. and Marquette Ave. A steam heating system will be installed in same. Total estimated cost, $800,000. Graham, Anderson, Probst & White, 1417 East Jackson Blvd., Chicago, Archs.

Minn., Minneapolis—The Northwestern Glass Co., 219 2nd St., N., plans to construct a 4 story, 66 x 162 ft. factory addition on 2nd Ave. and 2nd St., N. A heating plant will be installed in same. Total estimated cost, $100,000. Bertrand & Chamberlain, Northwestern Bank Bldg., Archs.

Minn., Minneapolis—B. N. Schneider, Plymouth Bldg., is having plans prepared for the construction of a 3 story, 90 x 120 ft. office building on 8th and Marquette St. A steam heating system will be installed in same. Total estimated cost, $300,000. Kees & Colburn, Plymouth Bldg., Archs.

Minn., St. Paul—H. W. Austin, City Purchasing Agent, is in the market for air lift equipment, electric driven air compressor with motor and vertical steel air receiver for the Como Park pumping station.

Minn., St. Paul—The city is in the market for 2 direct connected motor driven centrifugal pumps for the Water Department.

Minn., St. Paul—The Minor Hotel Co., c/o Hotel Magee, Roberts and 4th Sts., will soon award the contract for the construction of a 12 story, 100 x 100 ft. hotel. A steam heating system will be installed in same. Total estimated cost, $1,500,000. Mark Fitzpatrick, 17 West 19th St., Arch.

Tex., Abilene—The American Public Service Corporation plans to construct a 3 story power plant to furnish power for the towns of Anson, Merkel, Stamford, Hamlin and Cisco, also an ice factory to have a daily capacity of 100 tons. Total estimated cost, $700,000. A. Hargrave, South Western Life Bldg., Gen. Mgr.

Tex., Fort Worth—The North Fort Worth Ice & Cold Storage Co., 1015 North Main St., is in the market for pumps, air compressor, etc.

Tex., Navasota—The Chamber of Commerce will soon award the contract for the construction of a 2 story, 86 x 110 ft. ice and cold storage building. Estimated cost, $75,000. L. M. Heurt, Secy.

Wyo., Cheyenne—A. A. Boernsen, Arch., will soon receive bids for the construction of a 4 story, 200 x 200 ft. hospital on 23rd and House St. for Laramie County. A power plant will be installed in same. Total estimated cost, $300,000.

Okla., Perry—F. F. Busch, City Clerk, will soon award the contract for the construction of a dam in connection with the waterworks and electric light improvements. Separate bids will be received for furnishing hydrants, valves, two oil engines, 200 h. p. boilers, 4 panel switchboard, generators, etc. Black & Veatch, Interstate Bldg., Kansas City, Mo., Engrs. Noted April 1.

Okla., Wilson—J. W. Ryder, Engr., 614 C St., N. W., Ardmore, is in the market for two 200 h.p. boilers and one 200 h.p. engine for the city.

Ariz., Jerome—Lescher & Kibbey, Archs., Bank of Arizona Bldg., Phoenix, will soon receive bids for the construction of a 2 story, 40 x 130 ft. hospital, for the United Verde Extension Mining Co. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ariz., Nogales—The city plans an election to vote on $135,000 bonds to lay 14 in. steel water main, $37,000 to install pumping units and $15,000 to enlarge and repair reservoir.

Wash., Seattle—The Puget Sound Navy Yard plans to install exhaust fan, 11,000 cu. ft. of air per minute against static head of 6 inches of water when operating 1200 r.p.m.; also one motor driven air compressor set. S. E. Barber, c/o Puget Sound Navy Yard, Supply Officer.

Ore., Grants Pass—Grants Pass Irrigation Co. plans to install an 18 in. centrifugal pump in ditch 33 ft. above sea level, driven by 125 h.p. electric motor. G. A. Hamilton, Secy.

Ore., Warrenton—The city voted $500,000 bonds at recent election to etxend and improve the harbor. Project will include the purchase of 100 acres of land on the Columbia and Shipanon Rivers, for the erection of piers and docks, also installation of cranes and necessary apparatus for speedy cargo handling. J. Evenden, Aud.

Cal., Blythe—The City Council will soon receive bids for the construction of a well, 50,000 gal. tank on an 80 ft. tower, 400 gal. per minute pumping plant, etc. Bonds amounting to $36,000 have been sold for the project. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, Engrs.

Cal., Oakland—The Board of Supervisors of Alameda County will soon award the contract for the construction of a 4 story hospital on 14th Ave. and Vallecito Pl. A vacuum steam heating system and electric power system will be installed in same. Total estimated cost, $535,000. Henry H. Meyers, 1201 Kohl Bldg., San Francisco, Arch.

Cal., Santa Barbara—St. Francis Hospital, 6 Arrellage St., plans to build a 3 story, 200 ft. hospital, with two 2 story wings. A steam heating system will be installed in same. Total estimated cost, $175,000.

Cal., Yucaipa—The Redlands Yucaipa Land Co. will construct a water system in the Yucaipa Valley, consisting of several pumping plants, steel pipe lines and reservoirs. Total estimated cost, $100,000.

Ont., Holland Landing—The Township of Guillumbury has appointed E. A. James Co., Ltd., Engr., 36 Toronto St., Toronto, to prepare premliminary plans and surveys and submit estimates on the reclamation of 10,000 acres of a total of 80,000 acres of swamp land. Project will include low lift pumps, etc. Total estimated cost between $50,000 and $100,000.

Ont., Milverton—The town appointed E. A. James Co., Ltd., Engr., 36 Toronto St., Toronto, to prepare prelminiary plans and surveys and submit estimate of cost, for the construction of a distribution system and deep well pumps, pumphouse, water tower, etc. A centrifugal pump to deliver about 200 g.p.m. will be installed in same. Total estimated cost, $80,000.

Ont., Richmond Hill—The town engaged E. A. James Co., Ltd., Engr., 36 Toronto St., Toronto, to prepare prelminiary plans and submit estimates for the construction of a natural reservoir, pumphouse and a 7,500 gallon capacity elevated steel tank, also for furnishing duplex electric and gasolene turbine pumps with a capacity of 200 gallons per minute each, rapid sand filters, hydrants, valves, etc. Total estimated cost, $80,000.

Ont., Beaverton—The town has appointed James, Loudon & Hertzberg, Engrs., 36 Toronto St., Toronto, to make preliminary report on waterworks system. Plans include pump house, turbine pump, etc. Total estimated cost, $50,000.

Ont., Fergus—J. Alpaugh & Son have purchased a site and are preparing plans for the construction of a modern marble works plant. The owners plan to install a power plant in same. Estimated cost, $25,000.

Ont., Kitchener—F. McCutcheon, Star Theater, has purchased a site and plans to construct a 1 story, 80 x 100 ft. theater. A vacuum steam heating system with modern ventilating and cooling systems will be installed in same. Total estimated cost, $150,000.

Ont., Seaforth—The city retained James, Loudon & Hertzberg, Engrs., 36 Toronto St., Toronto, to prepare plans and estimates for the construction of a waterworks system. Plans include a pumphouse, centrifugal pumps, etc. Total estimated cost, $100,000.

Ont., Yorktown—J. & J. J. Allen, Richmond and Victoria St., Toronto, plan to construct a 2 story, 100 x 150 ft. theater and office building. A steam heating system and blower system will be installed in same. Total estimated cost, $125,000. C. Howard Crane, 2325 Dime Bank Bldg., Detroit, Arch.

CONTRACTS AWARDED

Mass., Boston—The First National Bank, 70 Federal St., has awarded the contract for the construction of a 108 x 171 ft. bank and office building on Milk St., to Stone & Webster Engineering Corporation, 147 Milk St. A steam heating system will be installed in same. Total estimated cost, $2,000,000.

Mass., Cambridge—The Whittemore Brothers Corporation has awarded the contract for the construction of a 3 story, 43 x 63 ft. storehouse on Albany St., to the Evatt Construction Co., 161 Devonshire St., Boston. A steam heating system will be installed in same. Total estimated cost, $150,000.

Mass., Cambridge—George H. Dyer Co., 155 Brookline St., has awarded the contract for the construction of a 2 story, 40 x 100 ft. addition to its factory, to F. J. Van Etten, 153 Milk St., Boston. The present heating system will be revamped and the company expects to spend over $10,000 for equipment in the spring.

Mass., Lynn—Hilliard & Merrill, 83 South St., Boston, have awarded the contract for the construction of a 5 story, 50 x 500 ft. warehouse on Eastern Ave., to W. M. Bailey Co., 88 Broad St., Boston. A steam heating system will be installed in same.

Mass., New Bedford—The New Bedford Hotel Co., Pleasant St., has awarded the contract for the construction of a 9 story hotel on Middle, Pleasant, High and Foster Sts. to the Longacre Construction Co., 185 Madison Ave., New York City. A hot water heating system will be installed in same. Total estimated cost, $1,000,000.

Mass., New Bedford—A. A. Spitz, Caesar Misch Bldg., Providence, R. I., has awarded the contract for the construction of a 3 story, 86 x 140 ft. theater on Elm St., to C. I. Bigney Construction Co., Inc., 898 Westminister, Providence. A steam heating system will be installed in same. Total estimated cost, $175,000.

Mass., Newton—The city has awarded the contract for the construction of a 2 story, 110 x 150 ft. school at Waban, to C. S. Cunningham & Sons Construction Co., 7 Water St., Boston. A steam heating system will be installed in same. Total estimated cost, $260,000.

Mass., South Boston—The Broadway Real Estate Trust Co. has awarded the contract for the construction of a theater and postoffice building to Fred T. Ley & Co., Inc., 499 Main St., Springfield. A steam heating system will be installed in same. Total estimated cost, $400,000.

R. I., Central Falls (Pawtucket P. O.)—The Fortuna Silk Mill, Clay St., has awarded the contract for the construction of a 4 story, 40 x 175 ft. silk mill addition, to the C. I. Bigney Construction Co., 898 Westminster St., Providence. A steam heating system will be installed in same. Total estimated cost, $100,000.

R. I., Providence—The Atlantic Tubing Co., 1756 Cranston St., has awarded the contract for the construction of a 2 story, 34 x 48 ft. boiler house on Cranston St., to C. I. Bigney Construction Co., 898 Westminster St.

Conn., Bridgeport—The American Fabrics Co., Connecticut Ave., has awarded the contract for the construction of a 2 story factory to the Aberthaw Construction Co., 27 School St., Boston, Mass. A steam heating system will be installed in same. Total estimated cost, $150,000. International Textile Co., lessee.

Conn., Bridgeport—Hincks Brothers & Co., 207 State St., has awarded the contract for the construction of a 1 and 3 story, 39 x 104 ft. business building on Main St. to Mark C. Treddenick Co., 1188 Main St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Conn., Hartford—The Hanson Whitney Machine Co., Bartholemew Ave., has awarded the contract for the construction of a 4 story, 60 x 120 ft. factory, to the Portens Walker Co., 13 Forest St. A steam heating system will be installed in same. Total estimated cost, $100,000.

Conn., Mansfield—The State Board of Education, Hartford, has awarded the contract for the construction of 2 and 3 story institutional buildings at the State Training School here to H. Wales Lines Co., 13 State St., Meriden. A steam heating system will be installed in same. Total estimated cost, $300,000.

Conn., New Britain—The New Departure Manufacturing Co., 269 North Main St., manufacturers of ball bearings, has awarded the contract for the construction of a plant consisting of 11 buildings, including a 1 story, 50 x 92 ft. boiler house and a 2 story, 40 x 130 ft. transformer house at the main plant, and a 1 story, 45 x 60 ft. boiler house at the north plant, to the Turner Construction Co., 178 Tremont St., Boston, Mass.

Conn., New Haven—The Y. M. C. A., 152 Temple St., has awarded the contract for the construction of a gymnasium and club addition to Y. M. C. A. building, on Howe and Chapel Sts., to the Larkin-Carey Co., 166 Brewery St. A steam heating system will be installed in same. Total estimated cost, $150,000.

N. Y., Brooklyn—The American Machine Foundry Co., 55th and 56th Sts., between 1st and 2nd Aves., has awarded the contract for the construction of a 6 story, 127 x 190 ft. factory addition on 55th St., to H. D. Best, 949 Broadway, New York City. A steam heating system will be installed in same.

N. Y., Little Falls—The Barnet Leather Co., 598 East Mill St., has awarded the contract for the construction of a 1 story, 40 x 50 ft. boiler house and a 1 story, 15 x 40 ft. pump room, to the Industrial Engineering Co., 30 Church St., New York City. Total estimated cost, $50,000.

N. Y., New York—The Amalgamated Centre, Inc., c/o G. A. and H. Boehm, Archs., 7 West 42nd St., will build a 7 story, 60 x 130 ft. club house on 2nd Ave. and 11th St. A steam heating system will be installed in same. Total estimated cost, $500,000. Work will be done by day labor.

N. Y., New York—The Fred F. French Co., 299 Madison Ave., will build a 16 story, 50 x 75 ft. office building on Madison Ave. and 41st St. A steam heating system will be installed in same. Work will be done by day labor.

N. Y., New York—E. Margolies, 19 East 33rd St., will build a 16 story, 56 x 150 ft. office building at 309-311 5th Ave. A steam heating system will be installed in same. Total estimated cost, $450,000. Work will be done by day labor.

N. Y., New York—The Monterey Hotel, Broadway and 95th St., will build a 62 x 100 ft. hotel. A steam heating system will be installed in same. Work will be done by day labor.

N. Y., New York—B. S. Moss, 729 7th Ave., has awarded the contract for the construction of a theater on Tremont Ave., to the Fleischman Construction Co., 531 7th Ave. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. Y., New York—Peck & Peck, 586 5th Ave., will build a 10 story office building. A steam heating system will be installed in same. Total estimated cost, $200,000. Work will be done by day labor.

N. Y., New York—St. Judes Chapel, West 99th St., has awarded the contract for the construction of a 5 story, 25 x 100 ft. parish house addition, to J. E. Wallace, 442 West 46th St. A steam heating system will be installed in same.

N. J., Atlantic City—Braustein & Blatt, 1420 Atlantic Ave., has awarded the contract for the construction of an 8 story, 110 x 150 ft. department store on Atlantic and South Carolina Aves., to Warren Moore & Co., 13th and Market Sts., Philadelphia. A steam heating system will be installed in same. Total estimated cost, $500,000.

N. J., Bayonne—The Board of Directors of the City Hospital has awarded the contract for the construction of a 4 story, 25 x 63 ft. hospital addition and power house on East 30th St., to the Franklin-Rocks Co., 354 West 24th St., New York City. Total estimated cost, $150,000.

N. J., Union—The Consumers Ice Co., 320 Fulton St., has awarded the contract for the installation of a freezing tank, 1 hoist crane and thawing apparatus, 2 can fillers, 4 brine agitators and 4 moles, to the Shipley Construction & Supply Co., 60 Warren St., Brooklyn. Estimated cost, $55,750.

Pa., Philadelphia—The Kensington Hygeia Ice Co., Trenton and Huntingdon Aves., has awarded the contract for the construction of a freezing tank with a 2 story, 30 x 30 ft., a 1 story, 31 x 100 ft., and a 1 story, 20 x 80 ft. additions, to Philip Haibach Contracting Co., 1261 North 26th St. Estimated cost, $25,000.

Pa., Philadelphia—Sears, Roebuck & Co., Arthington and Homan Ave., Chicago, has awarded the contract for the construction of a mail order plant, to consist of one 9

story, 300 x 442 ft. and one 6 story, 80 x 420 ft. buildings and power house, to Irwin & Leighton, 126 North 12th St. Steam heating systems will be installed in same. Total estimated cost, $4,500,000. Noted Sept. 30.

Pa., Philadelphia—H. O. Wilbur & Sons, Inc., 235 North 3rd St., has awarded the contract for the construction of a 7 story, 80 x 92 ft. power and warehouse on 3rd and Race St., to the Turner Construction Co., 1713 Sansom St. The first two stories will be used for the boiler room and power house and the upper stories for storage purposes.

Pa., Philadelphia—The Hulton Dyeing Co., 3819 Frankfort Ave., has awarded the contract for the construction of a 2 story, 62 x 400 ft. factory on Wheatsheaf and Canal St., to G. Crompton & Brothers, 4614 Oakland St. A steam heating system will be installed in same. Total estimated cost, $120,000.

Pa., Philadelphia—The American Preserve Co., 946 Beach St., has awarded the contract for the construction of a 5 story, 80 x 250 ft. factory and a 1 story, 50 x 70 ft. boiler house, on 3rd and Lehigh St., to Cramp & Co., Denckla Bldg. A steam heating system will be installed in same. Total estimated cost, $400,000.

Pa., Wilkes-Barre—The Y. W. C. A., Franklin St., has awarded the contract for the construction of a 1 story, 32 x 46 ft. boiler house, at 38 North Main St., to L. M. Leach, Pennsylvania Ave. Total estimated cost, $150,000.

Md., Cumberland — The ..Cumberland Amusement Co. has awarded the contract for the construction of a 1 and 2 story, 80 x 138 ft. theater on Baltimore St. to G. A. Fuller Co., Munsey Bldg., Washington, D. C. A steam heating system will be installed in same. Total estimated cost, $150,000.

Md., Towson Heights (Towson P. O.)—Black & Decker Manufacturing Co., manufacturers of special machinery, 105-15 South Calvert St., Baltimore, has awarded the contract for the construction of a 2 story, 100 x 200 ft. addition to its plant here to Austin & Co., 1821 North 5th St., Philadelphia, Pa., and Cleveland, Ohio. A steam heating system will be installed in same. Total estimated cost, $100,000.

Va., Norfolk—The Virginia Ice & Freezing Co. has awarded the contract for the construction of a 3 story, 150 x 200 ft. ice plant, to the White Construction Co., Inc., 95 Madison Ave., New York City. Estimated cost, $500,000.

N. C., Wilmington—The city has awarded the contract for the construction of a 3 story school to the Liberty Engineering & Construction Co. A heating system will be installed in same. Total estimated cost, $312,000.

Ga., Bainbridge—The Bainbridge Power Co. has awarded the contract for the construction of a dam and power house on Spring Creek, near here, to A. Dallen O'Brien, New Orleans, La.

Ga., Macon—The Atlantic Coal & Ice Co., Waterville Rd., has awarded the contract for the construction of five 1 story warehouses to the Foundation Co., 233 Broadway, New York City. A steam heating system will be installed in same. Total estimated cost, $250,000.

Ohio, Ashtabula—The city has engaged R. N. Case, former county engineer, to prepare plans for the construction of additions to the lighting plant. The first work will be the construction of a cooling tank. Estimated cost, $15,000. Work will be done by day labor.

Ohio, Columbus—John Immel & Sons Co., 81 East Livingston Ave., has awarded the contract for the construction of a new plant on a 6 acre site at High St. and Innis Ave., to Charles W. Schneider & Sons, Pennsylvania R. R., south of the Fair Grounds. The plant will consist of four buildings, including a 250 x 350 ft. main building, a 1 story, 40 x 60 ft. office building, a 1 story power plant and a dry kiln. Total estimated cost, $400,000.

Ohio, Norwalk—The Citizens National Bank has awarded the contract for the construction of a 5 story, 50 x 115 ft. bank and office building, to Mills & Millspaugh, 67 East Long St., Columbus. The heating contract will be sub-let by the general contractor. Total estimated cost, $200,000.

Ind., Indianapolis—The Polar Ice & Fuel Co., 20th and Northwestern St., has awarded the contract for the construction of a 1 story 47 x 90 ft. ice storage building on Western Ave. to W. P. Junglass, Indianapolis. Estimated cost, $50,000.

Mich., Alma—The Northern Wheel Co. has awarded the contract for the construction of a 2 story, 60 x 320 ft. factory to Henry H. Soule, Alma. A steam boiler, pump, etc., will be installed in same.

Mich., Detroit—The Anderson Electric Car Co., Milwaukee Junction, has awarded the contract for the construction of a 4 story, 100 x 187 ft. factory, on Alberle and Russell Sts. to H. G. Christman Co., 315 Stevens Bldg. A steam heating plant will be installed in same. Total estimated cost, $170,000.

Mich., Detroit—John J. Barium, 3061 West Grand Blvd., has awarded the contract for the construction of a 10 story, 30 x 36 ft. hotel and commercial building on Farmer and John Rd. to Otto Misch, Chamber of Commerce. A central steam heating plant will be installed in same. Total estimated cost, $125,000.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., has awarded the contract for the construction of a 10 story, 150 x 250 ft. service station on 2nd and Alexander Aves., to A. A. Albrecht Co., 1130 Penobscot Bldg. Boilers and general heating equipment will be installed in same.

Mich., Detroit—The Enterprise Foundry Co., Theodore and Beaufait Ave., has awarded the contract for the construction of a 1 story, 39 x 80 ft. power plant, to the E. D. Jackson Construction Co., Ford Bldg. Steam heating equipment will be installed in same. Total estimated cost, $10,000.

Mich., Detroit—The Freud Hotel Co., Hotel Addison, has awarded the contract for the construction of a 17 story, 100 x 100 ft. hotel on Witherell and Elizabeth Sts., to George A. Fuller Co., 540 Penobscot Bldg. Refrigerating equipment, etc., will be installed in same. Total estimated cost, $2,000,000.

Mich., Detroit—The General Carbonic Co., 542 5th Ave., New York City, has awarded the contract for the construction of a 1 story, 100 x 120 ft. manufacturing plant, a 40 x 50 ft. boiler house and a 25 x 30 ft. garage, to the Austin Co., 217 Broadway, New York City. A steam heating system will be installed in same. Total estimated cost, $75,000.

Mich., Detroit—Pittman & Dean Co., 203 Griswold St., has awarded the contract for the construction of a 2 story, 97 x 106 ft. artificial ice plant on Brush and Victor Sts., to Pine & Munnicke, 103 Marquette Bldg. Electric motors for power will be installed in same. Total estimated cost, $70,000.

Ill., Chicago—The Central Bag Manufacturing Co., 3622 Iron St., has awarded the contract for the construction of a 1 and 2 story, 330 x 400 ft. factory on Western Ave. and 60th St. to the Saleman Waterton Co., 343 South Dearborn St. A steam heating system will be installed in same. Total estimated cost, $350,000.

Ill., Chicago—The Central Manufacturing District, 38 South Dearborn St., has awarded the contract for the construction of a 6 story, 200 x 200 ft. warehouse on 39th and Winchester St. to the E. W. Sproul Co., 2001 West 39th St. A steam heating system will be installed in same. Total estimated cost, $800,000.

Ill., Chicago—The Chicago & Alton Railway Co., 608 South Dearborn St., has awarded the contract for the construction of a 1 story, 154 x 460 ft. freight house at 344 to 355 West Harrison St. to the Melton Stewart Nelson Co., 208 South La Salle St. A steam heating system will be installed in same. Total estimated cost, $1,000,000.

Ill., Chicago—The John Crerar Library, Marshall Field Bldg., has awarded the contract for the construction of a 15 story 80 x 80 ft. library and office building on Michigan Ave. and Randolph St. to G. A. Fuller Construction Co., 175 5th Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $1,250,000.

Ill., Chicago Heights—Carley & Hansen have awarded the contract for the construction of a 1 story, 75 x 125 theater to Engel Brothers, Chicago Heights. A steam heating system will be installed in same. Total estimated cost, $150,000.

Wis., Milwaukee—The Harley-Davidson Motor Co., 3732 Chestnut St., has awarded the contract for the concrete work for the proposed 6 story, 122 x 214 ft. shaped L factory addition on Chestnut St., to the Raulf Co., Patton Bldg. A steam heating system will be installed in same. Total estimated cost, $300,000.

Ia., Mitchellville—The city has awarded the contract for the construction of a pumping station, power transmission line and wells, to the Pittsburg-Des Moines Steel Co., 9th and Tuttle St., Des Moines. Contract does not include the furnishing of pumps for same. Estimated cost, $26,000. J. A. Kelley, Clk.

Minn., Duluth—The Duluth Telephone Co., East 1st St., has awarded the contract for the construction of a 4 story, 50 x 140 ft. telephone exchange on 1st St., E., to George H. Lounsberry, 322 East Superior St. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $250,000.

Kan., Wichita—The Board of Education has awarded the contract for the installation of a steam heating system in the proposed 3 story, 99 x 248 ft. Roosevelt Interstate School, to the McMahon Co., Kansas City, Mo., $82,500.

Mo., St. Louis—The Sugar Products Co., 16 Exchange Pl., New York City, has awarded the contract for equipping and installing a 500,000 gallon molasses storage tank, pumping station and equipment for transferring, also oil engine equipment, to P. A. Rohan, North First St. Total estimated cost, $30,000.

Tex., Breckenridge—The Texas Co., 17 Battery Pl., New York City, has awarded the contract for the construction of a steel compression plant and an absorption plant, to Westinghouse, Church, Kerr, Inc., 37 Wall St., New York City. A steam heating system will be installed in same. Total estimated cost, $150,000.

Tex., San Jose—The Stroud Manufacturing Association has awarded the contract for the construction of an auto factory, power plant, foundry and residences for employes to Bartlett & Ranney, San Antonio. Total estimated cost, $550,000.

Okla., Okmulgee—The city has awarded the contract for furnishing pumps in connection with waterworks system to the Merkle Machinery Co., 508 Interstate Bldg., Kansas City, Mo.

Ariz., Phoenix—The Geronimo Hotel Co., c/o Postle & Fisher, Archs., 140 South Dearborn St., Chicago, has awarded the contract for the construction of an 8 story, 138 x 205 ft. hotel to Paschen Brothers, 111 West Washington St., Chicago. A steam heating system will be installed in same. Total estimated cost, $750,000.

Wash., Spokane—The B. P. O. E. of Spokane has awarded the contract for the construction of a 2 story, 100 x 142 ft. temple on Riverside Ave., to Hurley Mason Co., Gasco Bldg., Portland. A steam heating system will be installed in same. Total estimated cost, $200,000.

Wash., Spokane—St. Luke's Hospital Association, Dean and A St., has awarded the contract for installing a steam heating system, including a 110 ft. stack, to Fred Phair, 416 Second St., Spokane. Total estimated cost, $30,000.

Cal., Los Angeles—Thomas B. Story, Story Bldg., has awarded the contract for the construction of a 13 story, 119 x 153 ft. office and stock exchange building, on Spring St., to Weymouth Crowell, 2026 West 9th St. A steam heating system will be installed in same. Total estimated cost, $750,000.

Cal., San Diego—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for a radio power house to Walter Slater Co., 2314 Santa Fe Ave., Los Angeles, $7500.

N. B., Riverglade—The Department of Public Works, Ottawa, Ont., has awarded the contract for installing a heating plant, etc., in the Jordan Sanitarium, here, to J. H. Doody, St. John. Total estimated cost, $24,547.

Ont., Ford City—The Separate School Board has awarded the contract for the construction of a 2 story school building to Wells & Gray, Confederation Life Bldg., Toronto. A steam heating system will be installed in same. Total estimated cost, $140,000.

Ont., Peterborough—The Board of Education has awarded the contract for installing a heating and ventilating system in the proposed 3 story collegiate institute, to R. C. Sturgeon, Peterborough. $32,145.